JOURNAL

OF THE

FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

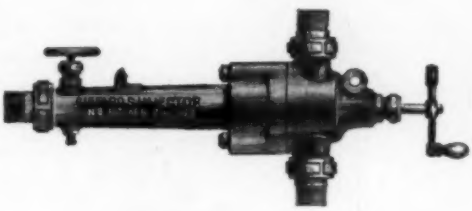
PROMOTION OF THE MECHANIC ARTS.

VOL. LVIII.] SEPTEMBER, 1869. [No. 3

EDITORIAL.

ITEMS AND NOVELTIES.

The Giffard Injector.—We were lately much interested in witnessing a very unusual performance by a Giffard injector of the self-regulating form devised by Mr. Wm. Sellers, and shown in the accompanying cut.

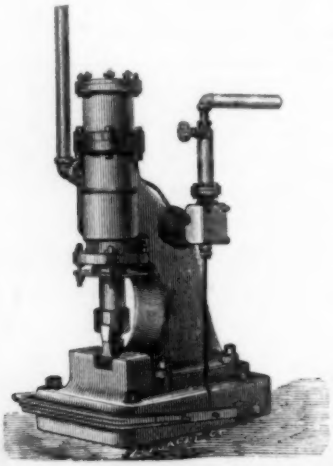


During the late water famine, from which our city has been suffering, attention has of course been drawn on all sides to any independent source of supply which could be rendered available.

Thus the Messrs. Sellers finding that in the basement of the new

foundry, which they are erecting on the other side of Hamilton Street, was a strong and constant spring, determined to place an injector immediately above it, and supply their boilers from that source. The distance between the boilers and injector is a little over 250 feet, and it might be supposed that such a distance as this would introduce serious practical difficulties in the working of the instrument. Such, however, has not proved to be the case. Owing to its self regulating capacity, no adjustment is required at the injector, no matter what may be the variations in the steam pressure. Large connecting pipes being employed, the only loss involved in this wide separation seems to be that due to radiation of heat, which, were the arrangement a permanent one, it would of course be easy to prevent by a free use of non-conducting material on the connecting pipes. When the return flow to the boiler is obstructed, a pressure of 80 pounds is produced in the injector from one of 60 pounds in the boiler.

The Joy Hammer.—This hammer is peculiarly adapted for drawing down iron or steel, in which operation a rapid succession of uniform blows is required, with only a gradual alteration in the force of the successive strokes.



It therefore becomes possible to dispense with the complication of separate valves, and thus remove much of the risk of derangement and source of wear.

In this instrument the ram contains openings which are brought by its own motion into communication with passages for the inlet and escape of steam, and thus cause its motion to be automatically reversed. The only valve in the hammer is the throttle valve governed by a treddle, and by the adjustment of its opening both the rapidity and force of the blows is at the same time regulated. As many as five hundred blows in a minute may be readily struck, and from the simplicity and solidity of all parts, there is the least possible chance of derangement.

A Big Belt.—The New York Belting and Packing Company

have lately had on exhibition at their store, New York, an india-rubber belt 4 ft. wide, 320 ft. long, and weighing no less than 3,600 pounds. It is intended for the main driving belt of the largest grain elevator in Chicago.

Hammering Iron until it is Red-hot.—In his lectures on "Heat," delivered recently at the London Institution, Mr. G. F. Rodwell alluded to a singular case of motion transformed into heat, namely, the rendering of iron red-hot by repeated strokes of the hammer. If Mr. Rodwell, who is so well versed in the history of science, will turn once more to the works of Robert Boyle, he will see that this "father of chemistry" had notions of the transformation of mechanical movement into heat very nearly akin to, if not quite identical with, those professed at the present day. Robert Boyle alluded to the rapid development of heat in an iron nail by repeated blows of the hammer *after it has ceased to travel* into the wood. It has been asked whether iron could be hammered cold until it became red-hot. Mr. Rodwell informs us that it can. Having requested a blacksmith to try the experiment, a piece of very tough iron was hammered with a moderately heavy hammer; it became hot, but would not scorch a piece of paper. It was then hammered by two men, one of whom used a sledge hammer, but with no better result. Presently, a man who was working in the shop said he had often lit his forge-fire by this means, before matches were plentiful. He took a nail, such as is used for horse-shoes, and, after hammering for less than two minutes with a light hammer, part of the nail was brought to a bright red heat. The blows were light but frequent, and the nail was partly turned at each blow.—*Scientific Review.*

The East River Bridge, U. S. A.—The plan of the East River bridge, as proposed by Mr. Roebling, has met with the approval of the Board of U. S. Engineers, appointed to examine it, and of the Government, and has been fully adopted by the Board of Consulting Engineers, consisting of Horatio Allen, William J. McAlpine, J. J. Serrell, Benjamin H. Lathrop, James P. Kirkwood, and J. Dutton Steele, who have made to the directors of the Bridge Company their final report, of which the following is the substance:—The plans, including foundations, towers, and superstructure have been laid before the Board by Mr. Roebling at various times between February 16 and April 26, and from him they have received the fullest information touching all the details. Having completed the

examination of the plans and the investigation of the combinations and proportions proposed, the Board deemed it an appropriate part of their duty to examine the structures of the same general character erected by Mr. Roebling across the Monongahela and Allegheny, at Pittsburgh, in 1846 and 1860; across the Niagara Falls in 1850, and across the Ohio, at Cincinnati, in 1860. They have thus had an opportunity of learning the successive steps in bridge building, which, beginning with a span of 822 in 1854, and one of 1,057 feet, in 1867, all standing this day—a practical demonstration of the soundness of the principles and proportions on which these structures have been erected, and rendering unnecessary, at least for spans of 1,000 feet, any other demonstration, and affording the best source of information as to the practicability of taking another step in a span of 1,600 feet. The bridge proposed by Mr. Roebling, a steel wire cable suspension bridge, 1,600 feet between the towers, 135 feet above the water, will be, in the opinion of the board, a durable structure of a strength sufficient to withstand six times the strain to which it can under any circumstances be subjected, that it will bear the action of the greatest storm of which we have any knowledge, and that the method of joining the parts cannot be surpassed for simplicity and security in the result.

Gas Blasting.—The "*Advertiser*" and "*Times*," Oswego, N. Y., says, "We saw a novel experiment involving the explosive power of gas. In the new tank excavation, now in a forward state, at the gas works in this city, an old well had been pumped out and then filled up, after leaving an aperture beneath. Into this space a limited quantity of gas was introduced from the gas pipe, sufficient to form an explosive compound with the air in the covered well. A match trigger touched off the mine, when a general upheaving of the surrounding earth took place, loosening up the soil and making easier digging."

A Rapid Change of Gauge.—In Missouri last month the Missouri Pacific Railway, a road nearly 200 miles long, changed its line from the broad to the narrow gauge. Nearly 1400 men were engaged in the work, and they labored with such celerity that the task was accomplished in twelve hours, and without interrupting the business of the road.

Explosion of Nitro-Glycerine at Cwymglo, at the foot of Snowdon. From various reports which have reached us, we gather that on Tuesday, a vessel, laden with nitro-glycerine, arrived at

Carnarvon Bar, the cargo being conveyed in boats to Carnarvon Pier. Next day, five cart loads were dispatched, two for Assheton Smith's Llanberis Quarries, and three for Lord Penrhyn's Bethesda Quarries. When the former two were near Cwymglo, the nitroglycerine exploded, blowing the horses and three men to atoms. The village, which is nearly a quarter of a mile off, was greatly injured, roof and windows blown off, and, at the spot where the carts were, two round holes six feet deep and seven feet diameter were made; the railway station, forty yards off, was blown to pieces. The whole valley at the foot of Snowdon and two large lakes suffered a severe shock, the damage done all round the valley being very great. The shock was felt at Bangor, which is about nine miles from the scene of the accident. There has been, of course, hardly time for details yet, but up to the time of our going to press it has been ascertained that four deaths had resulted from the explosion, and that twelve persons were severely and seven slightly injured. An investigation into the cause of the explosion was opened yesterday and adjourned. We shall have more to say on this matter in our next.

Eclipse Notes.—Determining "First Contact" with the Spectroscope.—One of the most beautiful observations made during the late eclipse was that of Prof. C. A. Young, on the first contact, by means of the spectroscope. Our readers are, no doubt, familiar, from former notices, (as on p. 87 of Vol. LVII.), with the method developed by Lockyer, of viewing solar prominences in the spectroscope without the aid of an eclipse. Prof. Young, as will be seen from his note, (p. 141 of our last number,) has been giving much attention to this subject, and has fitted up a very efficient instrument for the purpose.

During the eclipse of last month, he was stationed at Burlington, Iowa, and shortly before the first contact was due, he found that there was a solar prominence located at the spot where first contact must occur. (See F in cut on page 210.)

He therefore fixed his spectroscope with the slit radial to the solar edge at this point, so getting a prominence spectrum whose width was determined by the height of the prominence. Closely watching this, he presently found that it began to narrow steadily, and at the instant that it became a mere line and disappeared, he recorded first contact.

From the first photograph showing contact made by the Phila-

delphia party at the same place, Prof. A. M. Mayer, who had charge of that division, calculated the time of actual first contact, and found that it came within two-tenths of a second of the record made by Prof. Young.

Spectrum of the Corona.—During the totality of the late eclipse, Prof. Young gave special attention to observation of the corona with the spectroscope.

He found, that in place of a subdued solor spectrum which would have been anticipated from the reports of former observations, it yielded a spectrum of bright lines. The most prominent of these he was able to measure, and found its position as that indicated by 1474 on Kirchhoff's chart. Two other fainter ones were noticed, but there was no time to measure them. Prof. Young writes us, that he finds, by graphical projection, a close correspondence between this principal corona line and the brightest of the aurora lines observed by Prof. Winlock, on the 15th of April, and indicated by him as occupying the position of 1550 on Huggins' chart. Prof. Young also considers that the two fainter corona lines observed, but not measured by him, correspond with aurora lines 1280 and 1400 of Huggins' chart, observed by Prof. Winlock, on the occasion above noticed.

From these observations, Prof. Young hazards the conjecture that *the solar corona is, in fact, a permanent aurora.*

The Corona not Polarized.—With the above observations and deductions made by Professor Young, agree exactly those which were made at Mount Pleasant, Iowa, by Professor E. C. Pickering, who with a spectroscope observed no dark lines in the general light from the total phase, and with a polariscope arranged on the plan used by Arago in his study of sky—polarization, found no trace of this condition in the light from the corona. Professor Pickering's report in full will appear in our next number, and will contain a very ingenious and interesting discussion of these and other observations.

Solar Prominences as seen and as Photographed.—It will be remembered that in De La Rue's photographs in 1860, several prominences were conspicuously depicted which were not seen by any of the observers. This no doubt results from the great difference in actinic force between the light from the corona and prominences, when compared with their luminous intensity, the corona appearing intensely bright, but being very feeble in actinic effect,

while many of the prominences present an inverse order of the same properties. On the occasion of the late eclipse, the same thing was remarked, and when drawings and photographs come to be compared, this will be made manifest. We have already received some general information, from which it would appear that at the points marked B and C on the woodcut, p. 210, and shown on the photographic illustration in corresponding positions at either side of the spindle or ear of corn, only two pyramidal masses of white light, tipped with rose color, were seen, and that at F appeared a body having the shape of a mushroom, of a delicate rose color above, and white below.

Meteoric Shower During the Eclipse.—On p. 213 of this number, will be noticed some observations made by the Philadelphia party at Ottumwa, Iowa, bearing on this subject, and from Professor J. H. C. Coffin, U. S. N., we have just heard that Mr. Chas. G. Bœrner at Vevay, Ind., reports "several meteors were seen (during the eclipse), about 45° above the horizon, their path being in a westerly direction." Professor Coffin himself noticed the passage across the telescope from east to west, of several bright flakes resembling thistle blows floating in the sunlight, and yet so well defined that they must have been distant.

Solar Prominences.—In a late lecture at the Royal Institution Mr. Lockyer said as follows:—

"Although I find it generally best for sketching purposes to have the open slit in a radial direction, I have lately placed it at a tangent to the limb, in order to study the general outline of the chromosphere, which in a previous communication I stated to be pretty uniform, while M. Janssen has characterized it as '*a nireau fort ine gal et tourmente.*' My opinion is now that perhaps the mean of these two descriptions is, as usual, nearer the truth, unless the surface changes its character to a large extent from time to time. I find, too, that in different parts the outline varies: here it is undulating and billowy; there it is ragged to a degree, flames, as it were, darting out of the general surface, and forming a ragged, fleecy, interwoven outline, which in places it is nearly even for some distance, and, like the billowy surface, becomes excessively uneven in the neighborhood of a prominence. According to my present limited experience of these exquisitely beautiful solar appendages, it is generally possible to see the whole of their structure; but sometimes they are of such dimensions along the line of sight that they

appear to be much denser than usual; and as there is no longer under these circumstances any background to the central portion, only the details of the margins can be observed, in addition to the varying brightnesses. Moreover, it does not at all follow that the largest prominences are those in which the intensest action, or the most rapid change, is going on,—the action as visible to us being generally confined to the regions just in or above the chromosphere, the changes arising from violent uprush or rapid dissipation, the uprush and dissipation representing the birth and death of a prominence. As a rule, the attachment to the chromosphere is narrow and and is not often single; higher up, the stems, so to speak, intertwine, and the prominenc expands and soars upward until it is lost in delicate filaments, which are carried away in floating masses.

"Since last October, up to the time of trying the method of using the open slit, I had obtained evidence of considerable changes in the prominences from day to day. With the open slit it is at once evident that changes on the small scale are continually going on; it was only on the 14th inst., that I observed any change at all comparable in magnitude and radidity to those already observed by M. Janssen. About 9 hrs. 45 min. on that day, with a tangential slit I observed a fine dense prominence near the sun's equator, on the eastern limb. I tried to sketch it with the slit in this direction; but its border was so full of detail, and the atmospheric conditions were so unfavorable, that I gave up the attempt in despair. I turned the instrument round 90 degrees, and narrowed the slit, and my attention was at once taken by the F line; a single look at it taught me that an injection into the chromosphere and intense action were taking place. At 10 hrs. 50 min., when the action was slackening, I opened the slit; I saw at once that the dense appearance had all disappeared, and cloud-like filaments had taken its place. The first sketch, embracing an irregular prominence with a long perfectly straight one, which I call A, was finished at 11 hrs. 5 min., the height of the prominence being 1 min. 5 sec., or about 27,000 miles. I left the observatory for a few minutes, and on returning at 11 hrs. 15 min., I was astonished to find that part of the prominence A had entirely disappeared; not even the slightest rack appeared in its place; whether it was entirely dissipated, or whether parts of it had been wafted toward the other parts, I do not know,

although I think the latter explanation the more probable one, as the other part had increased."

Mr. Lockyer threw a fine picture of this storm in the sun upon the screen.

On the Means of entirely Preventing Bumping of Liquids while Boiling.—M. E. Winkelhofer.—The author reviews what has been done by others, and especially by Dr. Pellogio, and next describes, at length, some experiments of his invention, embracing the following fluids:—Methyl-alcohol, sulphuric acid, alcoholic solution of sulphate of protoxide of iron, alcoholic potassa solution, hydrochloric acid and dilute sulphuric acid, containing some sulphate of lead. His plan, to prevent bumping, is simply an electric current, led into the fluids by means of suitable conducting wires; his contrivances are very ingenious, but certainly too complicated for general use.

The Water of the Grenelle Artesian Well.—M. Stoelet calls attention to the remarkable fact that this water does not contain any dissolved oxygen, but only nitrogen, the quantity of which amounts to 14 c.c. to the litre of the water at 10° C. The total saline residue to the litre amounts to 0·142 grm.; the percentage composition of this saline matter is:—Carbonate of lime, 40·8; carbonate of magnesia, 11·5; carbonate of potassa, 14·4; carbonate of protoxide of iron, 2·2; sulphate of soda, 11·3; hyposulphite of soda, 6·4; chloride of sodium, 6·4; silica, 7·0. The same author has estimated the quantity, and determined the quality of the gases contained in rain-water fallen and collected in the neighborhood of Paris; 1 litre of this water gave 23 c.c. of gas composed, in 100 parts, of 2·4 parts of carbonic acid; the remainder was a mixture of oxygen and nitrogen, in the proportion of 32 parts of the former to 68 of the latter. M. Stoelet has discovered that the water brought up from the coal-pits contains a greasy matter, soluble in ether, and no doubt derived from the coal; from his observations at and about collieries, he draws the conclusion that this greasy or fatty matter makes the water unsuitable, and at times, even dangerous, for the use of steam boilers, since it may cause explosions.

Climate of the Isthmus of Suez.—Referring to this subject, M. Le Verrier read an abstract of a letter from Prof. Buijs-Ballot, the Director of the Royal Netherlands Meteorological Institute at Utrecht, wherein that gentleman states that the draining of the Harlem lake, in Holland, a surface of 19,000 hectares, has had the

effect of increasing the average summer temperature of that locality, and adjacent country, by ½°, and of decreasing the average winter temperature, also, by ½° C.

Very Durable Cement for Iron and Stone.—M. Pollack, of Bautzen, Saxony, states that, for a period of several years, he has used, as a cement to fasten stone to stone, and iron to iron, a paste made of pure oxide of lead, litharge and glycerine in concentrated state. This mixture hardens rapidly, is insoluble in acids (unless quite concentrated), and is not affected by heat. M. Pollack has used it to fasten different portions of a fly-wheel with great success; while, when placed between stones, and once hardened, it is easier to break the stone than the joint.

Improvement of Acid Waters often Pumped up from Coal-Pits and Mines.—Dr. Willigk.—The author had an opportunity to analise a water pumped up from a coal-pit in Bohemia. This water, it appears, was very acid, from acid sulphates and some free sulphuric acid present therein, consequently attacking and corroding the pumping gear and machinery, and seriously affecting the steam boiler wherein it had to be used. No other feed-water being on the spot, the author advised, and with good success, that the water should, previous to use, be filtered over witherite, carbonate of baryta, which happened to be abundantly present in that locality.

Volumetrical Estimation of Sulphuric Acid.—Dr. A. Clemm.—After reviewing the methods of R. Wildenstein and Carl Mohr, applied for this purpose, the author describes his mode of operating at length. Briefly stated, his method is the following:—The solution to be experimented upon is colored with litmus, and very carefully neutralised; a solution of chloride of barium of known strength is added in excess, and all the sulphuric acid thereby precipitated. Next, a titrated solution of carbonate of soda is added, in order to precipitate the excess of baryta; and next, again, the excess of soda solution used is estimated, volumetrically, by means of a titrated dilute sulphuric acid. During these operations, no salt is formed which can injure the color of the litmus. In case salts might be present in the original solution, the bases of which could be precipitated by carbonate of soda, that precipitation is performed previous to the addition of soda. The filtrate, which contains the sulphuric acid combined with soda, is neutralised, and again volumetrically titrated. The solutions required for this experiment are:—A solution of chloride of barium, containing 52

grms. to the litre of water; a solution of carbonate of soda, containing 26·5 grms. of this salt to the litre of water; a solution of sulphuric acid, containing 20 grms. of strong sulphuric acid to the litre of water. These solutions agree among each other, drop for drop. The advantage claimed for this method is the non-necessity of having to wash out the sulphate and carbonate of baryta, and also the advantage that titration does not take place in a fluid rendered turbid by therein-suspended sulphate of baryta, which always tends to render the observation of coloration of litmus more difficult.

Testing Chloroform for the presence of Alcohol and Ether.—The chloroform should be first treated with fused chloride of calcium, to eliminate any water, next some iodine should be added. If the chloroform is free from either alcohol or ether the color produced by the solution of the iodine is bright red; but when either alcohol or ether are present, the color of the solution is brown. In order to distinguish between alcohol and ether, a small piece of a crystal of fuchsin is added to the chloroform in question; when the slightest trace of alcohol is present, a deep red solution will ensue. Perfectly pure chloroform yields, with fuchsin, a solution which is only slightly pinkish tinged.

Salt Deposit near Berlin.—M. Jahn.—It appears that there has been discovered near Berlin, at Sperenberg, a rock salt deposit, which in some localities has a thickness of 669 feet. The locality where this important discovery has been made is within eight miles of the capital city of Prussia, and, from borings instituted, it appears in every respect, a highly valuable mineral deposit.

Sensitiveness of Divers Methods for the Detection of Arsenic.—M. Frank.—Marsh's apparatus admits of detecting 0·0003 milligramme AsO_3, dissolved in 150,000,000 of its weight of liquid; the method of Von Babo and Fresenuis admits of detecting 0·002 milligramme AsO_3; Reinsch's method, by means of copper, detects 0·001 milligramme AsO_3, in 5,000,000 as much liquid; Rieckher's method, by means of ammoniacal nitrate of silver solution, detects 0·002 milligramme in 3,000,000 parts of liquid.

Use of the Spectroscope to Distinguish a Feeble Light, Present with a Stronger Light.—M. Seguin.—The author describes a series of experiments with electric light, and observations thereon with Duboscq's vertical spectroscope. The result and conclusion arrived at is, that the spectroscope serves eminently the purpose of detecting (proved also by the other observations made

with it of the sun's light and protuberances) a more feeble light present with a much stronger, and the former of which would be invisible to the naked eye, or by means of other optical instruments.

Palladium and Hydrogen.—M. Fevre states that, according to his experiments, the hydrogen in palladium saturated therewith, is present as a chemical compound, and not simply in the state of condensed gas. The author also states that the vapor of boiling mercury is as little a conductor of electricity as hydrogen and that, therefore, the non-conductibility of hydrogen for electricity cannot be regarded as an objection to its being a metal.

Radiation of Heat from the Moon.—The Earl of Rosse is making a series of experiments by means of a thermo-pile of four elements and a 3-foot telescope, to determine, if possible, what proportion of the moon's heat consists of: 1. That coming from the interior of the moon, which will not vary with the phase; 2. That which falls from the sun on the moon's surface, and is at once reflected regularly and irregularly; 3. That which falling from the sun on the moon's surface is absorbed, raises the temperature of the moon's surface, and is afterwards radiated as heat of low refrangibility. The chief result arrived at up to the present moment is, that (the radiating power of the moon being taken as equal to lampblack, and the earth's atmosphere supposed not to affect the result) a deviation of 90° for full moon appears to indicate an elevation of temperature = 500° Fahr. The relative amount of solar and lunar radiation was found = 89819 : 1.

Action of Sunlight on Mineral Oils.—Some curious experiments, recently made by Herr Grotowsky, on the action of sunlight upon mineral oils, show that when the different kinds of petroleum oils are exposed to the influence of sunlight, they absorb oxygen from the air and convert it into ozone, as has been shown already for many other hydrocarbon oils by Shoenbein, Kuhlmann, and Phipson. According to Professor Grotowsky, no chemical combination occurs between the oil and the ozone; the latter remains free, and oxidizes powerfully any substances brought into contact with it. The odor of the oils is completely modified when they contain ozone;—the author states that they cannot be burnt, and that they rapidly attack cork. The color of the glass bottles in which the oils experimented on are enclosed, has a marked influence on this absorption of oxygen. Preserved in iron vessels, or completely out of the rays of daylight, all these oils may be pre-

served intact; but in white glass jars exposed to the light, the white oils become yellow, are highly charged with ozone, increase in specific gravity 0·005, burn with much difficulty, and attack the corks of the bottles. This is particularly the case with American petroleum.

Physiological Effects of Compressed Air.—Dr. G. von Liebig has made some new experiments on this subject, and concludes, 1. That the number of inspirations and expirations in an atmosphere submitted to a high pressure, when the animal has become accustomed to it, does not differ much from that which occurs in ordinary circumstances. 2. That the quantity of air breathed is not very different. 3. That the quantity of carbonic acid evolved is nearly identical in both cases.

Oxygen Developed without Heat.—Böttger, who devised the process, takes equal weights of peroxide of barium and peroxide of lead, and having mixed them together, adds some very weak nitric acid. Active effervescence immediately commences, and it is found that the gas evolved is pure oxygen. It will be seen that, according to Schönbein's theory, one of the peroxides employed evolves ozone, and the other antozone, or oxygen in the positive and the negative states, and these combine as they are given off to form neutral or ordinary oxygen. This process is of more scientific than practical interest; but it may be useful perhaps when small quantities of oxygen are required for medicinal purposes.

Bronzing Process, applicable to Porcelain, stoneware, and composition picture and looking-glass frames. The articles are first done over with a thin solution of water-glass by the aid of a soft brush. Bronze powder is then dusted on, and any excess not adherent is knocked off by a few gentle taps. The article is next heated, to dry the silicate, and the bronze becomes firmly attached. Probably, in the case of porcelain, biscuit, or stoneware, some chemical union of the silicate will take place, but in other cases the water glass will only tend to make the bronze powder adhere to the surface. After the heating, the bronze may be polished or burnished with agate tools.

Ventilation.—Gen. Morin, in giving an account at the Academie des Sciences of the successful application of his ventilating apparatus in a large weaving factory employing 400 work people, and in which were lighted 400 jets of gas, observed that its advantage might be judged of from the fact that during October, November,

and December, 1867, when the ventilation was defective, only 15,000 kilogrammes of bread were consumed, while, during the same months of 1868, after it had been improved, 20,000 kilogrammes were required, being a gain of 25 per cent. for the health and vigor of the operatives.

The Oxyhydrogen Light scheme has now taken a definite shape in Paris. A company has been formed, the capital necessary has been raised, and application has been made for permission to lay down pipes to carry oxygen and hydrogen over about a fourth of the city. It is not very likely that the permission will be granted, and the promoters will have to confine themselves to supplying individuals with compressed gases, as was originally proposed. We have published the patented processes by which M. Tessié du Motay obtains the oxygen and hydrogen which he proposes to distribute over Paris, at a cost so low that the oxyhydrogen light is promised much cheaper than common gas light; but ingenious and relatively cheap as they undoubtedly are, it is impossible to believe that the service can be made so inexpensive as to supersede coal gas. The prospectus of the company enlarges upon the cheapness and purity of the light, the complete combustion, and the absence of all deleterious matters in the products of the combination; but is quite silent as to the danger of introducing into a house two gases not possessing any smell, and which, consequently, may escape without observation, and the mixture of which forms an explosive compound of far greater power than any mixture of coal gas and air. To any danger of this kind, continental engineers appear to shut their eyes. We saw, a short time ago, a patent taken out in Belgium for making a mixture of coal gas and air, storing it in gas holders, and distributing it over the city of Brussels for heating purposes. The engineering details given showed a complete knowledge of the subject of the manufacture and distribution of gas, but there seemed to be no recognition of the risk, imminent enough, of blowing up the whole concern. A consideration of this kind, some years ago, stood in the way of a scheme of the kind projected for Birmingham, and will, no doubt, prevent the Oxyhydrogen Light Company from getting permission to lay down their pipes over Paris.

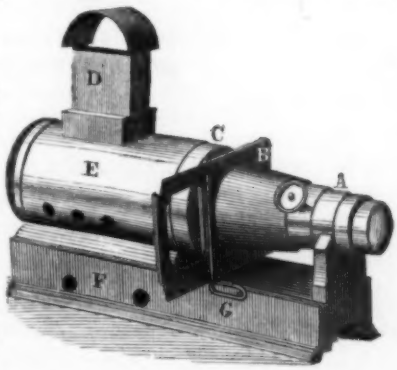
Ozone.—The information comes all the way from Tiflis, in Persia, that peroxide of hydrogen has been discovered in the air. Schönbein, who had no doubt of its existence in the atmosphere, never suc-

ceeded in demonstrating its presence. This success, however, is claimed by M. Struve. Along with the peroxide of hydrogen, the discoverer always finds ozone and nitrate of ammonia. These were also found in hail and in sea water. In these days, when the origin of nitrates of water is so warmly debated in connection with the question of the possible prevention of sewage contamination of water, we are fortunately reminded by M. Deville of the fact that he collected snow on the Andes, at the height of about 15,000 feet, which yielded a large amount of nitric acid, doubtless derived from nitrite of ammonia, which Struve has now discovered in the air.

Cornish Pumping Engines.—The number reported for May is 18. They have consumed 1,377 tons of coal, and lifted 10·2 million tons of water 10 fathoms high. The average duty of the whole is, therefore, 50,100,000 pounds, lifted one foot high, by the consumption of 112 pounds of coal.

Marcy's Improved Magic Lantern.—Our attention was drawn some time since to this very decided improvement in lanterns illuminated by ordinary flames, by which their efficiency is so greatly increased that many results can be reached which were heretofore only attainable by aid of the lime or magnesium lights.

The most important feature in this apparatus is the lamp, or as it might in this case be called from its appearance, the furnace. This source of action to the entire machine is placed in the cylindrical chamber E and provided with the chimney, D, and has two flat wicks one and a half inches long, parallel to each other and to the axis of the chamber, and in fact the optical axis of the instrument. The flames or rather sheets of flame that rise from these wicks are drawn together by the arrangement of the draft, and so form a pointed ridge or edge of intense light in the axis of the condensers, which are placed at C. We have on various occasions alluded to the fact long ago pointed out by Rumfort that flame was practically transparent. Here this property is utilized, and by reason of it we can get through the



condenser all the accumulated brightness of the long line of light, one and a half inches deep.

We have witnessed a number of experiments with this lantern, and can fully endorse it, as a great advance upon anything before used in the shape of a lamp-illuminated magic lantern.

For a parlor or school exhibition, it may well take the place of the far more troublesome oxycalcium lantern, which it rivals in efficiency.

There are many details of construction which are of very ingenious and efficient character, among which we would specially notice the slide for pictures, by which, one picture being in use, another may be removed and exchanged, and then by a single movement brought into the field, while the other is in like manner ready for substitution.

Analysis of the Hathorn Spring Water.—Professor O. F. Chandler, of the School of Mines, New York, has analyzed the water of Hathorn Spring, and certifies to the following solid contents found in a cubic gallon of water:—

Chloride of Sodium	509·968 grains.
Chloride of Potassium	9·597 "
Bromide of Sodium	1·534 "
Iodide of Sodium	·198 "
Fluoride of Calcium	a trace.
Bicarbonate of Lithia	11·447 "
Bicarbonate of Soda	4·288 "
Bicarbonate of Magnesia	176·463 "
Bicarbonate of Lime	170·646 "
Bicarbonate of Strontia	a trace.
Bicarbonate of Baryta	1·737 "
Bicarbonate of Iron	1·128 "
Sulphate of Potassa	none.
Phosphate of Soda	·006 "
Biborate of Soda	a trace.
Alumina	·131 "
Silica	1·260 "
Organic matter	a trace.
Total solid contents	888·403 inches.
Carbonic acid gas in one gallon	375·747 "
Density	1·009 "

The Borings for Rock Salt near Wylen, Switzerland, have given very favorable results. Near the Rhine, a bed of 80 feet in thickness has been found at a depth of 420 feet below the surface, and another 50 feet thick not far off. The salt is hard, pure, and of excellent quality.

Civil and Mechanical Engineering.

BELTING FACTS AND FIGURES.

By J. H. Cooper.

(Continued from page 109.)

Pulleys with Leather Covering.

"The sliding or slipping of belts on the pulleys is an evil experienced by almost every one whose business depends on machine power. Various means have been devised to avoid it. One of them is to strew powdered rosin or pitch on the inside of the belt. Another is to cover the pulleys with wood. A third is to give the rim of the pulley a curved surface. These means are only palliatives, and lack a thorough, steady and continued action. Rosin and pitch are soon pressed into the leather, when they not only lose their efficacy, but contribute to the rotting and destruction of the belts. A wood covering on the pulley gets polished in a short time, and is then as slippery as iron. It is therefore necessary to frequently roughen its surface, by which operation the diameter of the pulley is diminished, and the proportions of the transmission are altered. A convexity of the rim of the pulley is very effective to prevent the dropping off of the belt, especially when the pulley has a horizontal position; but it counteracts the slipping of the belt to but a small extent.

"We therefore take pleasure in communicating to the public a mechanical contrivance, which completely prevents the sliding of belts and all the great disadvantages resulting from it. It consists in covering with leather the working surface of the pulleys. As the friction of leather on leather is equal to five times that of leather on iron, and as leather can be roughened and be easily kept in that condition, it is evident that a sliding of the belts cannot take place on pulleys covered with leather, not even when the belts have to transmit the very highest amount of power. We have seen such pulleys working in sugar factories, breweries, in manufactories of German silver, in paper mills, machine shops, sawing mills, and in many other mechanical establishments, in all of which they have proved of eminent usefulness and great practical value.

With pulleys which have to run at a great velocity, as, for instance, those which drive blowers and saw-frames, as well as with pulleys of small diameter, which transmit powerful strains, the advantages of a leather covering are especially great. But besides these evident advantages resulting from the avoidance of the slipping, a leather covering on the pulley preserves the belt; in the first place, because the belt does not require tightening so hard, the friction being considerably increased; and in the second place, because there is no occasion for a rapid rotting of the belt. For this rapid rotting is generally caused by the fact, that under the influence of the heat produced by friction, the tannic and sebacic acids contained in the leather of the belts, combine chemically with some of the iron of the pulleys, forming a hard compound in the belts, which produces what is called rottenness, and frequently causes breakages. This evil is of course avoided by covering the pulleys with leather. * * * * * "The coverings are fixed to the pulleys by a kind of paste or glue, which hardens in a very short time, and sticks so well to iron and leather, that the greatest forces can be transmitted by the pulleys without loosening the leather. The operation of covering is very simple, and can be done and renewed by every intelligent workman. The price is $1\frac{5}{6}$ Prussian thalers per square foot of leather, including the glue."—Translated from Polyt Centralblatt. From Van Nostrand's *Eclectic Engineering Magazine*, July, 1869, p. 604.

To fasten Leather to Metal.

"A. M. Fuchs, of Bairère, says that in order to make leather adhere closely to metal, he uses the following method:—The leather is steeped in an infusion of gall nuts; a layer of hot glue is spread upon the metal, and the leather forcibly applied to it on the fleshy side. It must be suffered to dry under the same pressure. By these means, the adhesion of the leather will resist moisture, and may be torn sooner than be separated from the metal."—*Athenæum.*

Blake's Patent Belt Studs.

This approved device for fastening rubber and leather belting was patented April, 1860, and March, 1861, and re-issued August, 1868. Messrs. Greene, Tweed & Co., 10 Park Place, New York, have the sole right to make and sell this invention, and during the

last four years have supplied the studs to over ten thousand manufacturing concerns in the United States.

They are recommended to be better and cheaper than either lacing or hooks. When the above mentioned studs for fastening the ends of belts were tested on a 6-inch 4-ply rubber belt, the following result was obtained:—

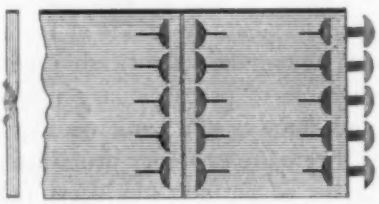
Belt hooks tore out under a strain of	.....	800	pounds.
Lacing " " "	.....	1690	"
Blake's studs held up to "	.....	4600	"

Where lacing or other methods of fastening are used, requiring punched holes, which weaken the material of the belt, the whole strain transmitted by the belt must be carried by a width section of the belt less by the sum of the diameters of the holes, which in usual practice is about one-third the width of the belt, whereas by the use of the patent studs, no punched holes are made, the material of the belt is not reduced, and nearly the whole section is available for strain, the stud being of such a form and inserted in such a manner as to grip nearly its entire width.

HALF SIZE.

Belts fastened by studs, are running now nearly four years, without repair. The ends of the belts are kept close together, and the studs do not touch the pulleys.

When belts have become too rotten to hold lacings, they can be fastened with these studs, which will hold until the belts are completely worn out. For damp places, these studs make a secure fastening.



In fastening the belts by these studs, the slit in a leather belt should be a $\frac{1}{4}$ inch, and in a rubber belt $\frac{3}{8}$ inch from the ends, and the studs inserted $\frac{1}{2}$ inch apart.

The cuts above give the form of the studs, the sizes made, and their position in the joint.

The smallest size is used for sewing machine belts, and the like, the next size say for 2-inch belts, and the largest for 4 and 5-ply rubber and double leather belts.

(To be Continued.)

LAYING CULVERTS UNDER THE BEDS OF RIVERS AND CANALS.

THERE is always more or less hazard and risk in disturbing what may be called the "existing state of things." Nevertheless, it becomes imperatively necessary, on certain occasions, to incur the risk of so doing. Of all the examples of engineering practice, in which a corroboration of this statement is to be found, that relating to interfering with the *status quo* of the beds and banks of rivers and canals affords the most conclusive one. Numerous have been the accidents and dire the consequences of excavating even in the approximate locality of these situations. It is impossible to observe too much caution in conducting operations of this nature, which have now become more frequent than formerly. This is partly owing to the fact that rivers are no longer regarded as inseparable barriers between their opposite shores, and that attention has, during the last few years, been prominently drawn to the practicability of effecting a communication underneath instead of overhead. This has been exemplified on a gigantic scale by the proposed submarine communication between England and France, and is being practically carried out by the Waterloo and Whitehall Pneumatic Company, and by the construction of the subway under the Thames at the Tower. Although not arrived at this pitch of subfluvial tunnelling, the French have accomplished something in that line, by the large syphon tube recently successfully laid under the Seine, to connect the sewage channels on each side of that river. The laying of culverts and pipes under embankments has always been a source of anxiety and trouble to the engineer, even when the embankments are made at the same time. It is needless to point out how greatly the trouble increases, and how much greater need there is of precautionary measures, when the case involves the undermining of a bank already *in situ*.

There are two very prominent instances to be adduced where the laying of pipes and culverts underneath the banks of water reservoirs were attended with leakage and bursting. The one is the well known catastrophe at Bradfield, some few years ago. The other is the leakage and subsequent emptying of the Vartry reservoir, constituting a portion of the Dublin Water Works. Whatever might have been the true cause of the former mishap, whether it was due to an error in the principle of construction adopted, or in practical working defects, there is very little doubt about the

latter. The extrados of the arch of the culvert was left nearly smooth, without any offsets, steps, or "racking-back," to afford a firm hold of the puddle of the bank. In fact, there was really a straight joint between the puddle and the masonry, whereas there should have been a union as intimate as it was possible for ingenuity to imagine. As might be expected, the water found out the "weak spot." The result was the emptying of the reservoir, which had taken months to fill, and the plunging of the Dublin Corporation into litigation, which entailed upon it a large amount of expense. In many of the towns where new sewage works are in course of construction, it has been necessary to lay iron pipes below the beds of the adjoining rivers and canals, both for the purpose of effecting a communication between the sewers upon the opposite sides, and also, in some instances, to constitute a channel of conveyance for the sewage to the fields intended to be irrigated. This subaqueous plan has been adopted at Norwich, where very extensive drainage and sewage works are in progress. Some idea of their extent may be gained from the fact that they are estimated to cost £60,000. Provided the foundation be good, and concrete be used liberally, the only point presenting much difficulty is the joints, which sometimes give a great deal of trouble. The depth to which the drains must be sunk depend, in the first place, upon the levels; and, secondly, upon the condition of traffic in which the river is placed. If the river be navigable, and used for the purposes of navigation, the pipes should not be placed too near the surface, and should be well protected, especially about the joints, with cement concrete, or they are liable to be damaged by the anchors of boats. Were there any choice in the matter, it would always be preferable to take the drain or pipe over instead of under the river, but it is seldom that the levels are so entirely optional as to afford the right of selection.

An instance of the bursting of a canal embankment, in consequence of excavating underneath it, for the purpose of constructing a culvert, occurred a very short time ago. It appears that a portion of the embankment of the Napton and Warwick Canal, on the Warwick side of the river, was washed away. The breach made was nearly forty feet in width, and the water escaping through it with great velocity completely inundated the adjoining fields, and did a great deal of mischief to the young crops and property. Although the conclusion is not absolutely an infallible one, that

the proposed construction of the sewer was the cause of the accident, yet, when it is borne in mind that the excavation was carried on in close proximity to the breach, it is difficult to trace the effect to any other cause. As a rule, we should prefer in these hazardous situations to lay cast iron pipes instead of building a culvert. The time which the disturbance and interference with the existing bank occupies is of equal importance with the nature of the operations carried on. A much shorter time will suffice to lay in a pipe than to construct a culvert of brick-work or masonry. The former will also require less excavation than the latter, for supposing them to have the same internal dimensions, the arch, invert, and side walls of the culvert, will necessitate the taking out of a considerable additional quantity of earth. These proportions in a cast iron pipe are simply its thickness, which practically is inappreciable. Besides, an increase in the capacity or internal size of the pipe, produces little or no corresponding difference in the thickness. With the exception of the difficulty sometimes experienced in making good the joints, there is no comparison with respect to the relative facilities of the two methods for establishing a speedy and secure communication between the opposite banks. The manner in which the canal is constructed, at the place where the intended pipe or culvert is to cross, has a very great effect upon the risk attending its successful laying. Should the canal be carried altogether in an embankment, and the levels not permit of the pipe being laid in the natural ground, but require it to be placed in the artificial bank, the danger is seriously augmented. Not only is the foundation more treacherous and insecure, but the earth above is more liable to subside than if it consisted of a thin stratum of the natural surface. Subsidence is not necessarily a forerunner of leakage or bursting, but it frequently does precede those serious contingencies, and may be regarded as a warning sign which should never be disregarded. A distinction must be drawn here between the ordinary subsidence, which invariably follows the erection of every new bank, a short time after its construction, and that for which there is no apparent cause. The former is always expected, and provision made accordingly for raising the bank to its proper level. The latter should be at once carefully inquired into, and a constant watch set on the spot.—*Mechanics' Magazine.*

THE BINGLEY EXPLOSION.

THE fatal boiler explosion at Bingley, which caused the death of fifteen persons, and injured about twenty-five more, has been the subject of investigation by Mr. L. E. Fletcher, Engineer-in-Chief to the Manchester Steam Users' Association. The examination was made at the instance of the coroner, who very judiciously adjourned the inquest pending Mr. Fletcher's report. That document has now appeared, and, from a perusal of its contents, it appears to us miraculous how the boiler lasted so long as it did. It was of the type usually employed in the Lancashire and Yorkshire mills, but was constructed of inferior metal, and so was wrong from the first. Previously to being put to work at Bingley, it had seen some eight or nine years' service in another establishment. When it left the latter place, it was purchased by a boiler maker, repaired, and re-sold. The repairs were necessitated by external corrosion underneath the boiler, but they were imperfectly done. Half-inch plates were riveted on to the old plates where they had become worn to a quarter of an inch. Thus patched up, the boiler lasted three years, when it exploded with the fatal effects we have mentioned. From an examination of the fragments, Mr. Fletcher found that leakage began at the junction of the old and new work. In more than one place, the plates were found to be reduced to the thickness of a sheet of paper—the old, old story. Of course, the shell gave way here, and the rent proceeding thence through the adjoining plates, soon completed the destruction of the boiler.

But the piece of patchwork was not the only fault the boiler had; it was badly equipped, and badly tended as well. The safety valve was too small and of defective construction, and the engine tender is believed to have been both incompetent and reckless—two conditions generally found associated together. Mr. Fletcher, however, very properly observes that some more practical lesson should be drawn from this fatal catastrophe than to throw the onus of fifteen deaths upon an ignorant stoker already killed by the explosion. The jury, however, returned a verdict of manslaughter against the dead stoker, and censured the owners of the mill for employing so incompetent an attendant and leaving him without supervision. They also recommend that all boilers should be brought under government inspection, and there the matter rests. But the circumstances attending the construction and use of this boiler call

for further remark here. We have over and over again pointed out how really preventable are those explosions, and that, therefore, they do not properly come within the meaning of the term "accident." It is needless to observe that this boiler was not under inspection, or it would have been condemned three years since. Had it been properly constructed at first, and placed under the protective inspection of one or other of the companies formed for this purpose, it is highly improbable that the recent catastrophe could have occurred. To guard against the possibility of bad material, Mr. Fletcher suggests that the plates used in the construction of boilers should not only be branded or stamped, like silver, with a certificate of quality, but marked also with the name of the manufacturer, so that the responsibility of the work could always be brought home to him. Then, with regard to the fittings, we all know how easy it is to meet ignorance or foolhardiness by safety valves of proper construction. In short, the Bingley explosion is only a repetition of an oft-told story, which must lead to protective legislation if repeated in the highly culpable form it has here assumed. Such events make us look with anxiety to the work the Committee of the Manchester Steam Users' Association have taken in hand, for promoting the security of life and property against unsound boilers. They propose that coroners should be empowered and instructed to command the attendance of competent engineers to give evidence when conducting inquiries in reference to these disasters. This would render unnecessary any government action, which might prove an interference with the freedom of the steam user, but to which he will inevitably have to submit if he does not mend his ways.

Road Watering.—All lovers of fair play will be glad to hear that Mr. Cooper's system of laying the dust by means of a solution of certain salts, is now in full and successful operation in Liverpool, with the cordial coöperation of the local authorities. Thanks to the inefficient supervision exercised by the Marylebone vestry, over the ignorant and interested servants whom they appointed overseers during Mr. Cooper's contract, and the consequent persecution and pecuniary loss to which that gentleman was subjected, there will be little chance of improvement for our metropolitan roads just at present. In Liverpool it is found that 75 per cent. of the work of water distribution is saved, but probably the most interesting fact elicited is that in streets watered on Mr. Cooper's system, sweeping may be practically dispensed with. This is a result worth noting.

THE LONDON WATER SUPPLY.

It is more than two years and a half since the Committee appointed to examine into the condition of the Metropolitan Water Supply commenced their labors but recently terminated, these being recorded in a report, the conclusions of which we have already published. The probable future metropolitan water requirements, and whether the source whence its present supply is derived will be sufficient and reliable in all ways for the coming generations, or whether we should begin to look elsewhere than to the Thames Valley for our main supply, were the questions which the Committee had to set themselves earnestly to consider, and, judging from the voluminous evidence they have received, from the personal examinations they have made, and from the care with which they have weighed evidence and studied the physical peculiarities of the basins of the Thames and of the Lea, we are bound to assume that their recommendations are correct, and that the Thames and the Lea, which have hitherto supplied London with water, will never fail, either in quantity or quality, in serving the metropolitan demand, even though it should grow and extend itself in a proportion which the increase of the decades of the past does not warrant in assuming for the future.

Two hundred millions of gallons of water a day is estimated as the future necessary supply for a population swelled to 5,000,000; nearly 200,000 tons of water distributed over an area of 224 square miles, through mains and branches and service pipes to meet individual demands, or public wants;—forty gallons being apportioned to each unit of the 5,000,000 every day. Times are changed, and necessities have increased since the city ran with sparkling streams from the high lands on the north of London, and carried a plentiful supply, which could be had for fetching: or since the local springs were collected and led by conduits through the city. The streams have long since disappeared, changed into sewers, arched over out of sight, and nothing but the names are left of the conduits to mark the course along which they ran. But these supplies were too limited even for London of the sixteenth century, and three hundred years ago came Peter Morrys, the Dutch engineer, who utilised the constant flood pouring through the narrow archways between the piled-up starlings of old London Bridge, to drive pumps that

raised water and supplied, by wooden mains and by open gullies, the neighboring streets for two centuries after his time.

In 1609, Hugh Myddelton commenced the formation of the New River, bringing the springs from the chalk at Chadwell and Amwell, near Ware, to within a few miles of London. Funds failing him then, the work was completed by the help of a royal grant, in doing which, by the way, royalty looked well after its own interests, and thus, seven years after the Act had been obtained, the northern parts of London were supplied by a plentiful flow, secured by gravitation. Soon after its completion the water from the chalk springs, which originally formed the only source, were supplemented by an inlet from the Lea.

These two works, together with the natural streams and open conduits, formed the water supply to London till the end of the seventeenth century. But in 1691 a company was formed under the title of the York Building Waterworks Company, to supply the city of Westminster, the water being pumped from the Thames near Charing-cross. These works existed so late as 1829. In 1723 came the Chelsea Waterworks to supply a district of Westminster and the growing neighborhood westward. At first the pumps were erected at Millbank, and afterwards removed to a site near to the present Victoria Railway Bridge. Meanwhile, the narrow arches of old London Bridge were filled with water wheels that clumsily raised water for the city as well as for Southwark. In 1785 the Lambeth Works had started and pumped their supply from the Thames opposite Charing-cross, and the Borough had established pumps not far from Blackfriars Bridge. With the beginning of the century most of the companies which now supply the metropolis came into existence. The West Middlesex Water Company at Hammersmith, in 1806, to supply the western suburbs; the Grand Junction, five years later, who, starting to draw their water from the Colne and Brent, aided by surface drainage, soon had to resort to the Thames for a purer and more constant supply, and in 1820 their sluices drew from the river near to Chelsea Hospital. Eastward the East London Waterworks, dependent for their supply upon the river Lea, superseded two small establishments at Shadwell and Ham; and shorly after their Act had been obtained, in 1806, works were erected near Bow. In the southern districts the Vauxnall Waterworks were started in 1805, taking their supply from the Effra, then an open confluent of the Thames, and but recently converted

into a covered sewer. The various companies thus established, before long, trading on their monopolies, began to levy rates, which resulted in a continued public dissatisfaction, and in 1821 a commission was appointed to examine into the subject. Their report, recommending considerable reform, was never officially acted upon, but it had the effect of inducing the water companies to remove the chief cause of complaint. The quality of water supplied was the next subject that claimed general attention. The various companies drawing their supplies from the river polluted by the sewage discharged into it, distributed it direct throughout their respective districts without any intermediate process of purifying. In 1828 a commission was again appointed to inquire into the quality of the supply. The examinations conducted by this commission showed that the general outcry was a just one, and that the supply, especially from the works below Westminster Bridge, was totally unfitted for general use. Filtering beds, settling reservoirs and removals to new sites followed the publication of this report. The Chelsea Company, in 1829, laid down the first large filter of one acre in extent; the West Middlesex and the Grand Junction removed their source from Chelsea to Brentford; the East London went higher up the Lea, and the Southwark and Vauxhall, combining, established new works at Battersea.

A report by Mr. Telford was made in 1834, in which it was recommended that entirely new sources of supply should be sought, and in which Mr. Telford suggested the Verulam on the northern, and the Wandle on the southern, side of the Metropolis; but this report, although discussed in both houses, remained entirely unacted upon.

The partial improvements introduced by the various companies after 1828 tided matters over for several years, but the development of sanitary engineering resulted in so largely increased a discharge of impurities into the river, that an efficient filtration became impossible, and it was obvious that the time had arrived when some of the most important companies must change their source of supply, or abandon their works altogether.

The Lambeth Company, situated in a most unfavorable position, were the first to take active steps towards the unavoidable change. In 1848 they obtained a new Act, and three years later water drawn from Kingston, far beyond the influence of the tide, was delivered through the mains of these extensive districts.

In 1850, the General Board of Health, who had by that time developed into a most useful and powerful body, issued a report, the minutes of which pointed out strongly the evils existing from the system of deriving a large supply from the tideway of the Thames, and, indeed, they went so far as to assert that the river should only be utilized temporarily for obtaining water beyond the influence of metropolitan drainage, until a more favorable locality could be decided upon, and centralized works erected; and they pointed out the large tract formed by the Bagshot sands, and the lower green sands in Surrey, as suitable for the purpose. This proposition might possibly have been acted upon had not a company at that time been projected for the purpose of supplying London with spring water from the chalk at Watford. The scheme had been so favorably noticed by Robert Stephenson, in a report made ten years before, that it was thought advisable for a commission to investigate chemically the quality of the water obtainable above the tidal influence. The result of their inquiry showed that such water could be thoroughly relied upon for public use, and, condemning the Board of Health proposition relative to turning to the Bagshot sand as a source of supply, they recommended the consideration of the Watford scheme, assuming that the hardness of the water derived from the chalk could be destroyed by Dr. Clark's process for softening.

The termination of all these investigations was a decision that legislation on the subject was necessary, and in 1851 a Bill was introduced into Parliament for the amalgamation and centralization of all the water companies, and the obtaining of all water from one common source. Opposition overcame this measure, but it resulted in an Act being passed the following year, by which stringent and important obligations were imposed upon the various companies, who were left otherwise free to pursue their business independently. The most important clauses of this bill rendered it compulsory that no water should be drawn from the river below Teddington, that all the city storage reservoirs should be covered, that all water, unless pumped from wells should be effectually filtered.

After the passing of this bill, the water companies proceeded to make alterations in compliance with its clauses, which involved an expenditure of 2,500,000 *l.* and with the result ascertained in 1856, of considerably reducing the amount of organic matter.

Of the eight companies now supplying the metropolis, five are

situated on the north side of the Thames, and three on the southern side. In the long series of articles published in the second volume of *Engineering*, under the title of "The Waterworks of London," the whole of these works were fully described in detail. The following table gives the general statistics of the various establishments in 1867:

	Capital.	Approximate Area of District Supplied.	Number of Houses Supplied, 1867.	Estimated Number of People Supplied, 1867.	Average Daily Supply, 1867.
From the Thames.	£	square miles.			gallons.
Chelsea Company.....	785,600	6·5	26,875	170,000	8,087,258
West Middlesex.....	798,571	10·0	36,881	275,000	8,816,486
Grand Junction.....	850,000	24·0	27,190	245,000	9,533,432
Southwark and Vauxhall.	1,100,440	30·0	71,558	465,000	13,629,758
Lambeth.....	736,245	25·0	38,320	230,000	8,975,530
From the Lea.					49,042,467
New River Company.....	2,609,418	19·0	113,462	800,000	23,790,667
East London Company....	1,400,000	50·0	92,652	675,000	19,298,241
From Chalk Well, Kent.					43,088,908
Kent Company	489,240	60·0	34,504	240,000	6,468,873
Total.....	8,769,514	224·5	441,442	3,100,000	98,600,248

The number of gallons given in the last column of the above table as the amount of daily supply gives only the average, and not the maximum quantity, which in the summer months is augmented to 108,313,000 gallons, showing an excess of 10 per cent. of consumption in the summer over the winter months.

Collectively the various companies possess forty-four subsiding reservoirs, occupying 260½ acres; the filtering beds number forty-eight, with an area of 51⅛ acres; they own twenty-eight storage reservoirs, having a capacity of 112,087,000 gallons, and ninety-six pumping engines, of 10,660 horse-power in all.

By their present acts and agreements the companies are empowered to draw 110,000,000 of gallons daily from the Thames—the

Chelsea, West Middlesex, Grand Junction, Southwark and Vauxhall, and Lambeth Companies,—each taking 20,000,000 of gallons, and the East London Company (under a recent Act) a quantity equal to 10,000,000 of gallons. From the Lea, the average quantities actually taken are: 18,000,000 of gallons by the New River Company, their total delivery being 23,750,000 gallons; and the East London take 19,250,000 gallons from the Lea, at a point lower down the river. Besides these quantities the chalk wells of the Kent Company yield 7,000,000 of gallons daily.

The commission of 1865, appointed to inquire into the best means of preventing the pollution of rivers, reported that the accumulating sewage discharged into the Thames by all the towns and villages along its course, tended seriously to impurify the river, and that efficient means should be taken to compel the diversion of the discharge, and the utilization of the sewage upon the land. The report resulted in the Act passed in the following year, which legislated for the towns along the Thames Valley, and fixed a limited time for the completion of the dictated improvements, a limit which, by the way, has been exceeded hitherto with impunity. This commission, and also the committee appointed in 1867 to inquire into the condition of the river Lea, were of opinion that with the recommended alterations, both rivers were efficient sources of supply, and that there was nothing to justify incurring a vast expenditure in the formation of new works.

The lengthened discussion which had taken place, and the epidemic which visited London in 1866 (the cause of which, it is alleged, might be traced to the water supply), brought forward many schemes for obtaining a pure supply from a foreign source; of these the principal were Mr. Bateman's project for utilizing the sources of the Severn; Messrs. Heman & Hassard's plan, looking to the Cumberland and Westmoreland Lakes; Mr. Fulton's project for drawing water from the Wye; and Mr. Remington's plan of obtaining it from the Derbyshire hills.

All these different systems, which have been fully described in previous volumes of *Engineering*, were carefully examined into by the recent committee, who concluded that, setting aside all other considerations, there was not sufficient information upon the reliability of the rainfall. It is evident, they say, "that a long series of observations is necessary to be made before any authoritative opinion can be expressed, not only as what may be the true aver-

age rainfall, but what may be the mean of the three driest years, and at what intervals they occur. In the case of a large city like London, where such a source of supply is proposed, an exact determination seems to us imperative. Of course it will be understood that not only should the observations extend over a long series of years, but also that they should be made in many places so as to get at the average rainfall of the district, which has well been shown to have very different values in immediately adjacent places, as it varied in the same year in fourteen areas in the lake district from 45 to 100 inches. The system of collecting grounds utilizes, no doubt, the rainfall to the greater extent. But the great disadvantage is, that the springs to fall back upon in time of drought, are insignificant in comparison with the great quantities stored in permeable strata. The very circumstance of a large immediate delivery of the rainfall precludes the possibility of that subterranean storage of a large portion of it which forms so valuable a resource during severe and long continued droughts."

These objections are substantiated by the experience gained from towns furnished with gravitation—supplies which have in nearly all cases failed in seasons of drought when the requirements were the most urgent. Liverpool, Manchester, Newcastle, Rochdale, Preston, Bradford, Halifax, and other towns suppled by this system, have all suffered from a temporary deficiency or even an absence of water, which involved the hasty extemporising of other means to meet the unexpected demands, or the erection of permanent pumping works to supplement the insufficient ones already existing.—*Engineering.*

THE PRESERVATION OF STONE

THERE is no name better known in connection with processes for making artificial, or preserving or hardening natural stone, than that of Mr. Frederick Ransome. It is now five and twenty years since, in 1844, Mr. Ransome first turned his attention to this department of scientific research, and during the whole of this time he has been an indefatigable experimenter, discovering obstacles only to surmount them, and never accepting more than a temporary defeat. With the successful results of Mr. Ransome's investigations, as exemplified in his well-known artificial concrete stone, our read-

ers are all no doubt familiar, and we need, therefore, merely allude to them here, the special object of the present notice being to give some particulars of a new process for preserving or hardening natural stone, which has been lately brought out by Mr. Ransome This process consists in successfully applying to the stone to be treated a solution or fluid mixture of lime or baryta, and a solution of silica, by preference an alkaline silicate.

The solution of baryta which Mr. Ransome prefers to employ consists of half a pound of baryta-hydrate to a gallon of water, and this solution is either applied to the surface of the stone by means of a brush, or, if convenient, the stone to be treated is entirely immersed in it. The stone having been saturated with the baryta solution to the required depth, its surface is next coated with a solution of soluble silicate or a mixture of soluble silicates, such, for instance, as a combination of silicate of soda and silicate of potash. This solution, which Mr. Ransome prefers, should be as nearly neutral as possible, and it may be made so either by adding gelatinous silica freshly precipitated from a weak solution, or by employing the process of dialysis to remove the excess of alkali. For general application it is found most convenient that the solution of soluble silicate should have a specific gravity of about 1·2, but this density may require to be increased or diminished in some cases; for instance, if the material to be treated is very porous, or if it is merely desired that the hardening should be effected to a slight depth only, a stronger solution may be used, and the same remark also applies to the solution of baryta. In some instances, also, Mr. Ransome proposes to employ a solution of lime in place of that of baryta, and, if necessary, molasses or sugar may be added to increase the quantity of lime held in solution.

Mr. Ransome has also brought out a modification of the above described process, in which the application of the solution of baryta, to the stone is preceded by the coating of the surface of the latter with a solution of superphosphate of lime of a specific gravity of about 1·06; or, if desired, the baryta solution may be applied first and the superphosphate subsequently. Mr. Ransome has, we understand, lately applied his new preserving process to the stones of the St. Pancras Station, and we hope in a future number to say more of its use and the results attending it.—*Engineering.*

OPENING OF KANSAS CITY BRIDGE.

Engineer's Test and Report.

THE Kansas City Bridge was formally opened July 3d, with appropriate ceremonies; the municipal authorities of Chicago and St. Louis, and an immense concourse of people participating.

The bridge consists of combination wood and iron trusses for spans 130 feet, 177 feet, 200 feet, and 250 feet, an iron span 70 feet, and a Linville & Piper patent wrought iron pivot span 360 feet in length. The superstructure was erected by the Keystone Bridge Company, of Pittsburgh.

The tests were made by careful instrumental measurements, the bridge being loaded with a train of five locomotives and cars loaded with railroad iron. The committee remark that they must meet the approval of all practical and scientific men, acquainted with the difficult problem of bridging with long spans such streams as the Missouri:—

Span 7. Length of Span 177 feet. Load at North. ¼ of span, 46 Tons.
North ¼ deflection ..... 14-32 inches.
Centre " ..... 10-32 "
Load at Centre and North ¼, 92 Tons.
North ¼ deflection ..... 24-32 "
Centre " ..... 31-32 "
South ¼ " ..... 28-32 "
Load at South ¼, Centre and North ¼, 112 Tons.
North ¼ deflection ..... 26-32 "
Centre " ..... 34-32 "
South ¼ " ..... 33-32 "
Span fully loaded, 170 Tons.
North ¼ deflection ..... 27-32 "
Centre " ..... 37-32 "
South ¼, " ..... 33-32 "
Elongation of bottom chord under full load ¼ inch, set after load passed off 1-16 of an inch.
Span 6. Length 200. Loaded with four Engines. Total weight 187 Tons.
North ¼ deflection ..... 42-32 inches.
Centre " ..... 54-32 "
South ¼ " ..... 41-32 "
Elongation of bottom chord ..... 11-32 "
Set ..... 13-32 "
Span 5. Length 250 feet, fully loaded 233 Tons.
North ¼ deflection ..... 51-32 "
Centre " ..... 69-32 "
South ¼ " ..... 48-32 "
Elongation of bottom chord ..... 3-8 "
Set ..... 5-32 "
Span 4. Length, 200 feet. Loaded, 187 Tons.
Centre deflection ..... 110-32 "
Set ..... nil

Draw Span 360 feet. North half of draw span loaded with 170 Tons.

North ¼ deflection	23–32 inches.
North Centre "	34–32 "
¼ adjoining drum deflection	15–32 "
Centre of South half, unloaded, rose under above load	19–32 "

Draw Span fully loaded, 313 Tons. On South half of span.

South ¼ deflection	9–32 inches.
Centre "	18–32 "
¼ adjoining drum	15–32 "

North half of Span.

Centre deflection	19–32 "
Set in South ¼ Truss	3–8 "
Set in North ¼ Truss	1–8 "

Time of opening draw 72° two minutes and ten seconds with four men. Elongation of Span, 2,130 feet in length under the moving load of five engines and loaded train was 7–32.

J. B. Moulton, late Chief Engineer North Missouri Railroad.

Walter McFarland, Major of Engineers, U. S. Army.

Geo. H. Nettleton, Chief Engineer, Hannibal and St. Joseph Railroad.

John B. Lodge, Engineer North Missouri Railroad.

Joseph S. Smith, Keokuk and Hamilton Bridge.

J. K. Thompson, Superintendent Bridges and Streets, Chicago.

A. Anderson, General Superintendent, Kansas Pacific Railroad.

D. J. Morrell, Superintendent Cambria Iron Works.

H. C. Moore, General Superintendent and Chief Engineer, Missouri Pacific Railroad.

The committee say:—

"The results were entirely satisfactory, reflecting great credit on all concerned in its construction, especially on the Chief Engineer, Mr. O. Chanute, who has shown the greatest scientific skill and administrative ability in its design and superintendence, and in successfully accomplishing the building of this, the first bridge across the Missouri River; the masonry of its piers having to be sunk from 40 to 50 feet below the bottom of the river, through quicksands and driftwood, in a turbulent part of the stream."

The opinion is expressed that the engineering profession will be greatly benefited if Mr. Chanute will publish a detailed statement of the building of this bridge, and the committee respectfully request him to do so at an early period.

KANSAS CITY BRIDGE.

FROM the *Missouri Republican* of St. Louis, we extract the following details of the structure and erection of the Kansas City Bridge, whose opening and Engineer's Test will be found fully described on another page.

Preliminary arrangements of charter and finance having been made, the services of Mr. O. Chanute as Chief Engineer were secured.

Mr. Chanute associated with him as assistant engineers Mr. C. H. Nickerbocker and Mr. G. S. Morison, and no time was lost in delay. He surveyed the river and the proposed location for the bridge and the customary routine of boring to find the rock was gone through in January, 1867. In February he gave up his residence at Chicago and came to Kansas City to superintend and conduct the operations. The location of the bridge was determined upon, and a point about opposite the centre of the town chosen. The works were commenced vigorously, and it soon became evident that the greatness of the task had not been at all over-estimated. A survey of the bed of the channel had been made, and the fixity of the latter being suspected, another one was made a short time afterwards. The second showed that it had sunk several feet. Again and again were surveys made; the bed would rise and fall, and where large deposits of sand had recently taken place, a huge depression would be noticed not long after. What, with the scouring and filling up, and the eating away of the bank and the continual shifting of portions of the bed, the engineer was driven almost to his wit's end. Still the river was there and it had to be bridged. Although the channel became twenty feet deeper in two months, and the obstacles were enough to dismay any ordinary man, Mr. Chanute attacked them with a bolder heart.

The eating-away process of the voracious monster went on quicker than had been counted upon, and actually 500 feet of the bank some distance above the site of the bridge was swallowed up and went down stream in five days. This would never do and it was decided to have recourse to riveting. Two miles of the southern bank were protected in this manner, the whole distance from the bridge site to the mouth of the Kansas River being riveted.

The history of the first year's operations was simply this, a struggle from beginning to end with the river and its ever-changing bed.

Temporary works—piles driven into the sand were undermined and swept away, and at one time Kansas City was threatened with a sand bar, which would leave it isolated, so far as river navigation was concerned. "Necessity is the mother of invention," and Mr. Chanute did discover a method by which the majesty of science was asserted over an unchecked and uncontrolable body of water.

The current being very swift and powerful, it was found impossible to build the foundations of the bridge in the ordinary manner, and an ingenious plan of protection was devised. A bottomless caisson was lowered by means of screws which were fastened to a timber frame, itself secured to the rock by drills. Another caisson was secured by cables a little distance up stream to break the force of the current. After the caisson had been lowered it was made water-tight, and the work proceeded. This plan was specially adopted for pier No. 1. With the other piers sheet piling, false works, dredges and syphons, and the making of caissons water-tight by bags of concrete placed around them by drivers, were had recourse to. The caisson for pier No. 2 was peculiar, being like a round barrel some forty feet in diameter. Many of the piles were sunk by the aid of a water jet.

The foundation of pier No. 4, writes an engineer connected with the works, presented the greatest difficulties, and as finally carried out was the most successful. The caisson built and partially sunk in the fall of 1867 remained in position until the following March, when the river in two days scoured away twenty feet of sand on the side next to the channel, causing the caisson to tilt rapidly toward the south, till it fell over, and became a total wreck. It was then necessary to begin this foundation anew, and for greater security it was decided to dispense with piles and found the pier directly upon the rock. As the work must be done in the low-water season of fall and winter, when the deposit of silt and sand is the greatest, it became necessary to go through nearly forty feet of deposit, twice as much as at any other pier, to a depth fifty feet below the ordinary stage of water. To accomplish this, the bold and novel plan was adopted of substituting a masonry pier for the bottomless caissons used elsewhere, and sinking this pier bodily to the rock, building up as it descended; the pier being guided in its descent by suspension screws, and the material removed from below by endless chain dredges working in wells left in the masonry. To avoid the delay which the obstructions of the old wreck would have

entailed, the site of the pier was shifted fifty feet to the south, putting the two hundred and fifty feet span between piers four and five. A timber caisson seventy feet long, twenty-two and a half wide and twelve feet high, with pointed ends, was built on the shore to carry the masonry. It was built with double walls, the outer vertical, and the inner inclining inward and upward, the two uniting at the base in a sharp, cutting edge, shod with iron, and made with three cross-walls of similar form. This caisson was proportioned to carry the entire weight of the pier, and to resist all pressures and disturbances which might come upon it. Some idea of its strength may be derived from the fact that 60,000 feet of lumber, mostly oak, and 22,000 pounds of wrought iron were used in its construction. While the caisson was building on shore, the false works were in progress at the pier site; they rested on sixty piers, which were surmounted by seven trusses capable of carrying a thousand tons, or, if absolutely necessary, double that weight. Twenty-four suspension screws, twenty feet long, and from two and a half to three inches in diameter, were placed in the truss-frame above, and twenty-four two and a half inch rods, in corresponding positions, were built into the caisson, passing through the timber sides from top to bottom, and taking hold below the main sill. On the 21st of October, the caisson was launched and floated into position. It was then suspended from the trusses, the false bottom removed, and the caisson lowered till it rested on the sand in nine feet of water. After filling the spaces between the double walls with concrete, the outer wall was surmounted by a planked frame wall twelve feet high, built with a slight batter, and the spaces left between the inner and cross-walls, by four rectangular boxes, which formed the walls of the dredge wells. This second section was also filled with concrete. At the same time the dredging machinery was mounted above, and a house built over the entire work, to protect the workmen and machinery from the weather and facilitate the prosecution of the work both night and day. The false works were arranged in three separate stories. The lower floor, only a few feet above water, was reserved for the use of the carpenters and masons engaged in building the successive sections of the caisson and laying the masonry. This floor contained also the engine-room and divers' houses, with air-pumps and apparatus, while an extension built out on the north side furnished runways to carry off the sand thrown out by the dredges. The second floor, entirely housed in, contained the shaft-

ing and connections by which the dredges were run—each dredge being inclosed by itself to confine the splash of sand and water—the machinists' work-benches, superintendent's office, lamp room, etc. On the third floor, immediately under the roof, were placed the crabs used in raising and lowering the dredges. The dredges were of the endless chain pattern, arranged specially for this work, with vertical telescopic frames, by which the working length was increased as the pier descended, the frames being also easily moved up and down, independently of any change in length, by the crabs.

On the 28th of December, everything being in readiness, the machinery was set in motion and the sinking began. The dredges were easily driven by a single twenty-five horse-power engine, and little difficulty was found in securing a uniform descent by the aid of the suspension screws. The material first excavated was a fine, sticky silt, which could be dredged only when mixed with a large quantity of water, forming a thin mud; the rate of descent was, however, materially faster than either concrete or masonry could be laid. The second section of the caisson was in turn surmounted by a third, within which the cut-stone masonry of the pier was laid, the planking serving as a protection from the sand. It was found best not to sink both night and day as the splash from the dredges greatly inconvenienced the masons, and the plan was adopted of working the dredges by night and laying masonry in the daytime. As the pier descended the character of the material excavated changed to a coarse heavy sand, easily dredged, and the progress became more rapid, six inches being sometimes accomplished in a single hour, while it was easy to go down in six hours as far as the masonry could be built up in eighteen.

A delay of a few days was occasioned by striking on two sunken piles, which probably belonged to the old wreck; one of these was removed by the divers, and the other tied up and held till the edge of the caisson broke through it; the timber was ten inches thick where it broke, and showed a ragged broom-like fracture. On the 6th of February, the masonry having been stopped a day or two before, the pier came to a bearing on a mass of clay and boulder, through which it was worked slowly about a foot in the usual way. A force of eight divers was then engaged to finish the excavation; they worked in alternate gangs day and night in the chambers of the lower section beneath the masonry, removing the boulders one by one. The stones were of various sizes, from small pebbles to

two hundred and fifty pounds weight, closely packed together, and showing no signs of wear by water; among them were found occasional masses of clay, pieces of water-charred wood, a number of teeth, and an Indian arrow-head. By the 10th of March the divers had worked through four feet of these boulders, and brought the pier to a bearing on the bed-rock. The small amount of sand which remained inside was then cleared out, the dredge removed, and the wells filled up with concrete; the false works were stripped to the lower platform, a derrick mounted, and on the 2d of April the laying of masonry was resumed, the last foundation being finished. On the completion of No. 2, the force on this pier was doubled, and the last stone in the bridge laid on the 5th of May, 1869.

Most of the difficulties incidental to the construction of the bridge have been mentioned in the foregoing, and we will now notice the structure as completed.

The general impression created on first viewing the bridge from a distance is a very favorable one, and which is strengthened on approaching nearer to it. It presents a substantial appearance, although the superstructure is light. The distance from the water to the roadway of it at the present stage of the water is 32 feet, at low water 47 feet, and at high 11 feet.

From the abutment on the Kansas City shore to the two pillars at this end of the bridge the distance is 66 feet. The abutment is a massive one, and the pillars are 7 feet square at the base, and also 7 feet at the top, while they are 5 feet through the neck.

The piers have a curved cornice, and are formed like an Egyptian pillar. The "ice-breaker" at their bottom tapers toward the top, and has a sharp point. There are, in all, seven piers.

Pier No. 1.—The distance from the pillars to the first one is 134 feet. It rests on a rock, is 100 feet from the shore, 63 feet in height, 65 feet by 20 at base, and 40 feet by 10 feet at the cornice; 8 feet through the neck. The distance from it to pier No. 2 is 181½ feet.

Pier No. 2.—This is the round pier on which the draw swings. It is 40 feet at the base, 29 feet through the neck, and 33 feet at the cornice. It rests on a rock, and is 66 feet high. Distance to pier No. 3, 181½ feet.

Pier No. 3.—This is distant from pier No. 4, 200 feet; is 79 feet in height, 70 feet by 21 feet at base, 40 feet by 10 feet at the top, and is 8 feet thick at the neck. It rests on rock.

Pier No. 4.—The span to pier No. 4 is 250 feet; height of pier, 90 feet; 70½ feet by 22½ feet at the base; 38 feet by 9 feet at the top; 7 feet at the neck. It rests directly on a rock.

Pier No. 5.—The span between this pier and pier No. 6 is 200 feet. Dimensions: At base, 70 feet by 15 feet; at top, 38 feet by 9 feet; neck, 7 feet; height 56 feet. Rests upon piles driven to the rock.

Pier No. 6.—Span to pier No. 7, 177 feet. Size of pier: 60 feet by 13½ feet at bottom; 38 feet by 9 feet at top; neck 7 feet; height 75 feet. Rests upon piles driven in the sand.

Pier No. 7.—The dimensions of this pier are: At bottom, 40 feet by 11½ feet; 36 feet in length at top; 45 feet high; 6 feet through the neck. It rests upon 75 piles driven into the sand, which is 10 feet below low water.

The masonry of the piers is of limestone, quarried in the neighborhood; the facing is of ashlar, and the backing of heavy rubyle.

The Superstructure.—The superstructure is composed of iron and wood. The contract for it was taken by the Keystone Bridge Company, of Pittsburgh. The short shore span is a riveted trellis girder of wrought iron. The other fixed spans are double triangular trusses, of a pattern designed for this bridge; the lower chord, and all parts strained in tension, are of wrought iron, the top chord and braces of wood; the three longest spans have curved upper chords. The construction of the bridge is such that any portion of the superstructure can be replaced, in a few moments, without interfering with the passage of trains. This does not decrease its stability.

The superstructure rests upon cast iron bed-plates on rollers in an iron case, to allow for the contraction and expansion of the iron work, caused by the changes in temperature. The roadway is laid with Nicolson pavement, and the rail is what is known as a strong steel rail. It was rolled especially for this purpose, is much heavier than they usually are, weighing sixty-eight pounds to the lineal yard. It is adapted both for steam cars and ordinary carriages. The bridge has been constructed with a view to the allowing of buggies and wagons to pass over it when not in use by the railroads. There is a footpath along the side for its entire length. After the celebration a toll will be charged, probably 4 or 5 cents for a single person, and about 50 cents for a buggy. The roadway is 18 feet wide, and the footpath 4 feet.

The Draw.—Perhaps the most interesting portion of the structure is the draw. It is 363 feet in length from the centre of pier No. 1 to the centre of pier No. 3, and is entirely of wrought iron. It is of Linville & Piper's patent. The "draw protection" in the river is the same length as the draw, and "rests" are placed on cribs which were sunk filled with stone. When the draw is swung round to permit a steamboat to pass, its ends will rest on these. The draw is easily worked by four men, with wrenches; it is intended to place a small steam engine on pier No. 2, to work it The draw works very nicely.

The gauge of the track on the bridge is the narrow gauge of 4 feet 8½ inches. The track of the Missouri Pacific Railroad is now 5 feet 6 inches, and it is understood that it will be altered to the narrow one, which is used by all the other railroads connecting at this point. The track on the bridge is a single one.

The distances from the track of the bridge to the centre of the spans are respectively 22 feet, draw 35 feet, 25 feet, 31 feet, 25 feet, and 22 feet.

A telegraph wire of the Western Union Telegraph Company is carried over by the bridge.

The bridge is estimated to carry one ton to the foot. At this weight the wrought iron is only strained up to 10,000 pounds the square inch, and the timber to 400 pounds. This is twice as much as it is ever likely to carry. On the test, to-day, it will be subjected to the weight of seven locomotives, extending from end to end. It is estimated that it will carry four or five times this weight, and ten times the actual weight ever likely to come upon it in service.

The deflection, when the greatest weight that can be put upon it is done, will be 1¼ inch for the 188 feet span, 1½ inch for the 200 feet span, and 1⅞ inch for the 250 feet span.

The bridge has been partly tested already, and trains have passed over it, with two locomotives and two cars loaded with iron, weighing 100 tons. The deflection of the 250 feet span is 1⅜ inch.

Other Work.—Beyond the northern end of the bridge there is 2,363 feet of trestle work, 30 feet in height; this is over the bottom lands to the high grounds. On the opposite shore there has been a deep cutting, 1,400 feet in length and 73 feet deep in the middle. Further on there has been rock cutting 1,000 feet in length by 40 feet in height. The railroads on the south side make their connec-

tions with the track at the end of these cuttings, and those on the northern side of the Missouri at the end of the trestle work.

Quite a picturesque view of the surrounding country is obtained by a person standing in the centre of the bridge. There is a sudden bend in the river here, and looking west up the river, the pretty little town of Wyandotte, Kansas, is seen straight ahead, on the south or west bank of the river. A short distance below, the State line is distinguished by a belt of timber on the Kansas border. On the northern side of the river, a little below the bridge, there is Harlem, the terminus of three railroads, destined to receive some of the benefits that will flow from this enterprise. The high bluffs of Kansas City are on the southern side, and a cute, wide-awake person who owns a lot near the terminus of the bridge can be seen washing the bluff away with a stream of water forced up from the river, in hose, by a stationary steam engine. A laborer directs the nozzle at the base of the bluff. The hill melts and flows in a thick muddy stream down a trench, again to mingle with the turbid waters below, after having been solidified for centuries. The owner of the dirt is progressing with the demolition. This, however, is a digression. Opposite Kansas City there is nothing but a few shanties in the primitive forest, and it is rumored that they are to form the nucleus for a "New Kansas City." Lots have risen from $100 to $1,000 per foot.

A large number of trees and branches are coming down the Missouri, and quite an accumulation has taken place at the western end of the "draw protection" and some of the piers. They will only, like masses of ice, beat harmlessly against them.

The railroads which will be enabled to connect at Kansas City, by means of this enterprise, are the Kansas City and Cameron Railroad; North Missouri Railroad; Missouri Valley Railroad; Missouri River, Fort Scott and Gulf Railroad; Missouri Pacific Railroad; Missouri River Railroad, and Kansas Pacific Railroad.

The connections will be equally beneficial to all these roads, and, if to any specially, to the St. Louis roads. The roads which ran on the northeast side of the river were the North Missouri; the Missouri Valley Railroad running to St. Joseph; and the Kansas City and Cameron Railroad. The Missouri River Railroad is the road which is operated in connection with the Missouri Pacific, and runs to Leavenworth. The Missouri River, Fort Scott and Gulf Rail-

road has 55 miles constructed, south, and is being pushed to the Indian Territory.

The total cost of the bridge has been about $1,000,000. It may slightly exceed this, but very little. The contract for the superstructure was $250,000, and this is included in the sum, In this $1,000,000 there is also included the cost of 2,363 feet of trestle work, the 1,400 feet of cutting, and the 1,000 feet of rock cutting before referred to.

No account of this bridge would be complete without a word respecting Mr. O. Chanute, the Chief Engineer. He has won deserved fame in his profession, and has cause to be proud of this last signal achievement. He is an affable and courteous gentleman, and has been ably assisted by Mr. C. H. Nickerbocker, G. S. Morison, and Mr. T. Tomlinson, the latter of whom had charge of the iron work.

Local Attraction.—Colonel Sir Henry James, Director-General of the Ordnance Survey, reports that during the past year inquiry has been prosecuted into this very remarkable phenomenon. He observes that the relative extent to which the plumb line, and the levels of our astronomical instruments, are affected in a country where there is nothing on the surface of the ground to account for it, may be judged from the fact that it is nearly double the amount of the deflection on Schehallion mountain, 3,547 feet high, with the instrument placed on the sides of the mountain itself, at one-third of its altitude, the position to produce the greatest effect from the mass of the mountain on the plumb lines. He considers that we have very decided indications that the cause is in the granitic rocks which extend in a south-west direction from Cowhythe through Banffshire, and which are highly impregnated in some parts with magnetic iron in a metallic state. The range of mountains on the south-east of Banffshire culminates in Ben Muich Dhui, 4,305 feet high, which, after Ben Nevis, 4,368 feet high, is the highest mountain in Scotland. The great amount of the attraction at Cowhythe, and along the coast to the east and west of Portsoy, cannot be explained by anything visible on the surface, and obliges us to imagine the existence of some large and very dense mass of matter underneath it. Sir H. James hopes to resume this important inquiry this season; and the geological structure, as well as the mineral character of the rocks, will be carefully investigated by the Director of the Geological Survey of Scotland.

Mechanics, Physics, and Chemistry.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

By Dr. Adolph Ott.

"Le probleme de la conservation des bois est une question qu 'on peut mettre au premier rang parmi les questions les plus importante d' economic publique." *Dumas.*

Early Trials. The effects of Metallic Salts. Experiments made on German Railroads.

"Wood is an outgrowth of the earth, by which nature provides for the payment of our debts," was the utterance of Lord Carnarvon, during the then raging gambling mania under Charles II. of England. Many a venerable old forest had to fall, in order to cover the losses at the play-table of but one evening. Is it to be wondered at, that from this time dates the first attempt for protecting timber from rot? It originated with the German chemist Glauber, and consisted in first charring the surface of the timber, then coating it with vegetable tar, and immersing it in the acid from wood. From the past century date also various methods for preserving timber. They are founded either on the application of tarry, oily or resinous substances to the surface of the wood, or on its immersion in various fluids. These processes are likewise found to be alternately applied. The present century, as may be expected, has brought forward a great number of inventions with regard to this subject. The usual methods consist in drying the timber by hot air; in lixiviating it by cold water, steam, or chemicals; in its immersion in various liquids; or, in impregnating the same with fluids by means of pressure, after expelling the sap. Boucherie's process, which is the only original one of its kind we are acquainted with, consists in displacing the sap of the living, or felled and squared tree, with saline solutions.*

* The first patent of Dr. Boucherie dates from the year 1838. It is founded on the ascending force of the sap, which causes the preserving fluid to pass through the stem upwards to the ramifications. The latter is brought in contact with the juice through a circular saw-cut at the base of the standing or with the entire surface of the cut of the sawed down tree. The "*green log cured in the forest*" became at that time the object of great wonder. In 1841, Boucherie proposed another method by which the expelling and displacing of the juice is effected by

The preserving fluids now chiefly employed are metallic and saline solutions, and the products of the destructive distillation of coal and wood. Most metallic salts, as well known, form scarcely soluble, and not readily putrefiable, compounds with albuminous matter; these latter form, to a large proportion, the contents of the vegetable organs, and, being exceedingly liable to spontaneous decomposition, constitute, in most instances, the decay of the ligneous tissue, or of the fibro-vascular bundles around the pith, of which wood, properly speaking, is composed. In effecting, therefore, such combinations in the interior of the wood, it was supposed that they would be the means of effectually arresting this transformation. In doing so, it was, however, not taken into account that those compounds are themselves easily soluble in a surplus of the metallic solution, or in the albuminous juice itself.*

By the usual methods of injection, a thorough saturation of the wood is but rarely effected, and although it may be taken for granted that as long as the preservative fluid remains in the interior of the cellular tissue, no decomposition will ensue, this will most assuredly be the case when the fluid in question has been removed by the action of either terrestrial or meteoric waters. Aside from this, the investigations of a very careful observer, Mr. Koenig, seem to prove that the metallic salts unite more readily with the resins than with the albumen of the wood. His researches extended over various kinds of timber which had been impregnated with copper and zinc solutions. He ascribes the temporary preservation of timber to the formation of a "resin soap," as he terms that compound, which, in covering the fibre, affords some protection against the growth of fungi or the attacks of insects. It was found that non-resinous wood absorbs very little of these metallic salts, and sulphate of copper, when injected in wood from which the resin had been removed by boiling it in alcohol, could easily be lixiviated by laying the thus saturated wood in water. Steamed oak absorbed more chloride of zinc than green or seasoned oak, a fact which may be accounted for when it is known that in steaming, the pores are widened while

pressure. The preserving fluids chiefly employed by him are sulphate of copper, pyroligneate of iron, and chloride of calcium. This process has since been adopted by several railroads, and for impregnating the telegraph posts in France. Four years ago, a certain Mr. Hamar obtained from the United States a patent for a similar process, the alleged merits of which we shall examine presently.

* Vide Lehrbuch der organischen Chemie von T. E. Schlossberger. Leipzig and Heidelberg. 1857; page 144.

the resin remains.* These facts fully explain, as reported in one of the annual meetings of the German Civil Engineers, why not less than 46·59 per cent. of the pine sleepers of the Kreuz-Bromberger Railroad, which had been treated with blue copperas, had to be removed after only ten years' service.†

Injection with Brine. Salting Timber.

With regard to the injection with brine after the method of Boucherie, it may be stated that it failed like many others, to give the satisfaction required. That the external application of salt, as practised for increasing the durability of timber in vessels, must be still less satisfactory, is self evident.

In an excellent article on the ship-timber in the United States, prepared expressly by Mr. William W. Bates, of Chicago, Illinois, for the Commissioner of Agriculture, the author speaks‡ as follows, on the alleged utility of salting:—

"There can be no doubt of the utility of salting close assemblages of timber, provided the pieces are not too large; but if large, not too green. The action of salt upon timber seems to be imperfectly understood. It is seldom applied to advantage, as may be seen from the mode of using it, namely, against the dry sides of the timbers instead of the moistened ends, which is rather impracticable. It results that water from the wood is very slowly obtained, which is shown from the length of time it takes to dissolve the salt —several years. During this time, incrustations are formed over the surface of the wood; these are cooled and preserved, *but the interior of the timber, especially if large, not having parted with its moisture and fermentable juices, may be decomposed, as we have seen, despite the salt.* From this we are led to infer that a proper application, either in mode or quantity, would have saved the interior as well as the outside of the timber. But this is by no means certain, however. *Salt, in its nature, it is not constituted to perform all the functions of a perfect antiseptic for timber, and, besides, is too slow in its action.* If the timbers of a ship could be made small enough

* Aus der Natur. Die neuesten Entdeckungen auf dem gebiete der Naturwissenschaften. 1863; page 598.

† Chemisch technisches Repertorium von Dr. Emil Jacobsen. 1864; 2d half year, page 8.

‡ Report of the Commission of Agriculture, for the year 1866 Washington, 1867.

in scantling, salt might answer to save them; but salt would scarcely save an ox were the carcass not cut up, and it is equally useless applied to timber. It is also a most weighty and cumbersome material, and would be more so, if applied to the extent required."

[The italics are by the author of this article.]

The Process of S. Beer.

Quite recently attention has been called to a process for preserving timber, invented by S. Beer, in New York. The same consists in the treatment of the wood in a boiling solution of borax in water, and came to our notice through a German periodical of last year.* It is claimed therein that all the putrefiable substances are effectually removed by the borax; moreover, it is held that the ligneous fascicles become harder and less absorbent, that the treatment protects the wood from insects, keeps it dry and inflammable. The process itself is carried out in the following manner: In a vessel of wood or iron a saturated solution of borax in water is prepared, the quantity of which must be sufficient to cover the timber. The temperature of the solution is then raised to the boiling point, either by introducing steam or otherwise. This is kept up for two to twelve hours, according to the porosity and density of the timber, when the operation is repeated with a new and concentrated solution. At this time, the wood is only kept for half the period in the liquid. It is now withdrawn, and when dry, is ready for use should its hardness and color not present objections.

Let us now examine this process a little closer. The fact that borax is soluble in about twelve parts of its weight of cold water, makes this process inapplicable for structures which are to be exposed to terrestrial or meteoric waters, for the reason that the intended protective coating will be slowly removed. Again, borax being of a hygroscopic nature, if not refined with the utmost care, will soon absorb water, and thus leave the wood in a damp, instead of a dry state. Naturalists in selecting borax crystals for their collections, well know that they have to coat them with a varnish, or otherwise they would soon become white and opaque, on account of their affinity for water. But a still more serious objection against this process consists in the property of alkaline fluids, such as a solution of borax; of dissolving or at least attacking certain sub-

* The Gewerbeblatt feor das Grossherzogthum Hessen. No. 22; 1868.

stances of the wood upon which its strength, solidity and toughness, and other desired properties greatly depend. Those substances are the so-called incrusting materials. They form in concentric layers the inner walls of the ligneous cells, they being abundant in the hard woods, and the stones of fruits, when they often fill the entire space of the cell. In the making of paper from wood, all that is wanted is the supple, pliant cell. The manufacturers' attention is therefore directed to the removal of the non-fibrous bodies, which end he accomplishes by the boiling of the previously reduced wood in alkaline lyes, but the paper obtained, though smooth and elastic, and capable of taking the highest finish, lacks that degree of firmness necessary to make it a fitting material for better kinds of paper. In the course of this article, I shall have occasion to dwell fully on the importance of the natural resin contained in timber in its bearing on the durability of wood. It is certainly not an advantageous feature of the above described process, that the resin is altogether removed by it; and in regard to its claimed superiority in withdrawing the putrefiable substances, it may be stated on good authority (experiments conducted at the College of the City of New York), that not less than 14 per cent. of the original amount of albumen have been retained in sawdust after boiling the same several times, and each time for hours, with a saturated solution of borax.

Coal Tar, and its products, as preservatives of Wood. The experiments of Professor Rottier.

The products of the destructive distillation of carboniferous bodies belonging to the coal series have often been recommended for the purpose in question. Some have preferred the light, others the heavy oils, some force the preservative in the wood while in its liquid state, others endeavor to accomplish the same end by exposing the timber to its vapors.

It is not my intention to enter into the history of the various trials and their results; with regard to these, I refer to an ably written article in the *Scientific American*, June 12, 1869, entitled "Coal Tar, and its products as preservatives for Wood." My purpose is simply to relate some experiments which were undertaken by *Mr. Rottier*, Professor of Chemistry at the University of Ghent, Belgium, in order to determine what ingredients of the coal tar are most effectual in protecting wood from rot. An account of these

experiments may be found in the *Breslauer Gewerbeblatt* of 1865 (page 152). Rottier's experiments extend over the following constituents of coal tar:—

1. The light oil.
2. The oil containing carbolic or phenylic acid.
3. The oil containing aniline.
4. The napthalized oils.
5. The solid resoden.
6. The green, fluorescent oil distilling between 275 and 320 centigrade, containing pyren and paranaphthalin.

(To be continued.)

ON THE COMPUTING AND COMPARING OF INDICATOR DIAGRAMS.

Read before the Polytechnic Society of the American Institute, April 29th, 1869.

By G. H. Babcock.

It is a fact well known to engineers, that by none of the ordinary methods of expressing the comparative merits of different engines, can a satisfactory conclusion be reached as to the value of any peculiar construction, unless all the conditions and circumstances under which the comparison is made are precisely similar. The amount of coal burnt per hour per horse-power is a common criterion, but so many other conditions than that of the construction of the engines enter into and affect the result, such as the evaporative efficiency of the boiler, the quality of the fuel, the load, the amount of protection to the boilers and pipes, from radiation, etc., that it affords no just criterion by which to judge the perfection of the engine alone, unless these several conditions are all equal in the classes in which a comparison is desired.

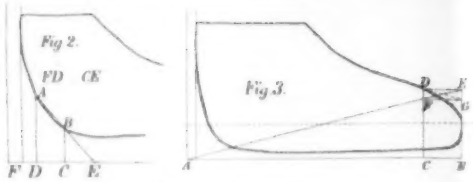
The amount of water required per hour per horse-power gives a much nearer approximation to the relative value of different engines; but in this comparison, also, it is necessary that the load relative to the capacity of the engine, the quality of the steam, whether dry or wet, and all the exterior conditions should be precisely similar, to render the comparison just. But even when the exterior conditions are similar, neither of these tests give any result by which can be determined, save by inference, the relative advantages of different mechanical arrangements or proportion of parts. It being almost impossible, except by special construction for the purpose of experiment, to find two engines under circumstances where the sole difference is in some specific point of arrangement or proportion, the precise effect of that difference cannot be determined by the consumption of fuel or water.

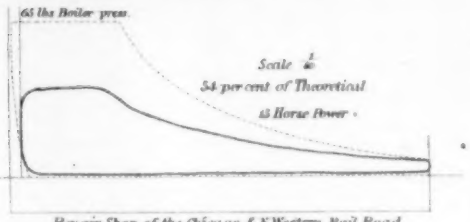
The use of the indicator is the most satisfactory way yet devised for ascertaining the relative efficiency of various constructions and styles of engines, under differing conditions; the shape of the diagrams produced by this instrument giving to a practiced eye—but only to such—an indication of the relative perfection of the valve-motion, the size of the passages, and the general efficiency of the machine. But it is desirable to be able to compute these diagrams in some way which will give a mathematical expression of their several grades of efficiency, and thus enable us to express the comparative values of different forms of construction, independent of the varying conditions under which the diagrams have been taken, and a method of accomplishing this object forms the subject of the present investigation.

It is evident that an engine which has no losses from clearance, condensation or leakage, which takes the steam at boiler pressure until the point of cut-off, expanding in accordance with the hyperbolic formula, exhausting at the end of the stroke to atmospheric pressure, or to perfect vacuum, according as it is condensing or non-condensing, performing the back stroke with no back pressure (back pressure being reckoned from atmosphere if non-condensing or vacuum if condensing), and compressing if at all, on the hyperbolic curve, would give the utmost power which could be obtained practically from that amount of steam used under that pressure and degree of expansion. And it being self evident that the engine which approaches nearest in its action to the above has the best proportions and arrangement of its mechanism, we will adopt it as a standard and proceed to institute a comparison of the diagram made by a given engine, with this standard engine having the *same capacity* (including clearance) *and using the same amount of steam with the same boiler pressure;* that is, we propose to compare each diagram with a diagram calculated for a theoretically perfect engine under precisely similar circumstances.

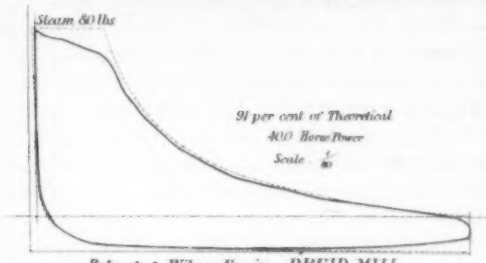
The amount of steam expended in producing the power developed in any particular case, is measurable in two ways: by the amount which enters the cylinder, and by the amount which is discharged therefrom. Had we the exact means of measuring either of these quantities, we should, of course, find them precisely equal; but owing to the unavoidable condensation within the cylinder, part of which is reëvaporated during expansion, and of more or less leakage into the cylinder after the valves are closed, the indicator diagram nearly always shows an apparently greater quantity of steam exhausted than received. The exact point of cut-off or suppression is, in most cases, also very difficult of determination by means of the diagram, while it is not difficult to decide upon the point of exhaust, with sufficient accuracy for our present purpose; consequently a nearer approximation to the true amount of steam used may be obtained by measuring the steam exhausted than by the induction.

Indicator Diagrams





Repair Shop of the Chicago & N. Western Rail Road
Cyl. 15" Dia. 35" Stroke 26" Revol.



Babcock & Wilcox Engine DRUID MILL
Cyl. 28 ins Dia 72 ins Stroke 46 ft Revol.

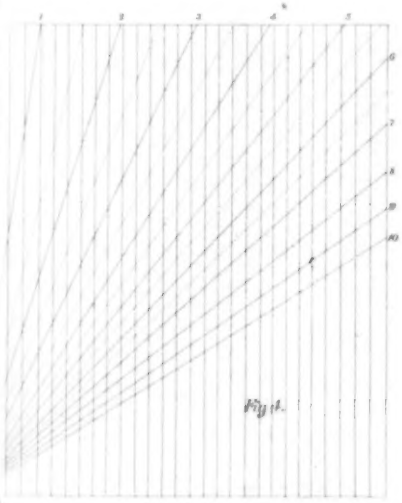
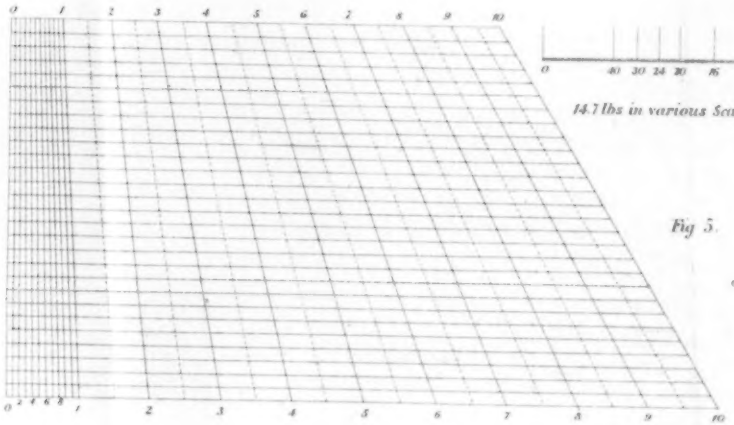
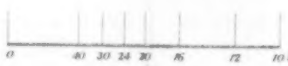


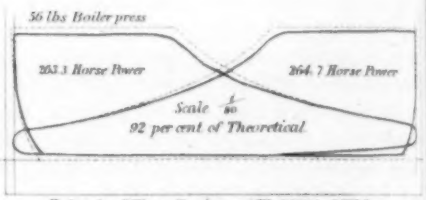
Fig 4.



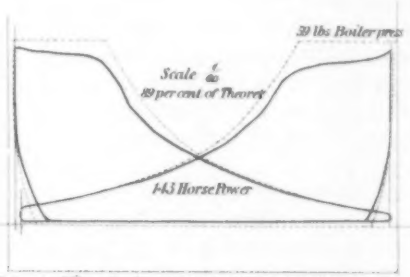


14.7 lbs in various Scales.

Fig 5.



Babcock & Wilcox Engine ATLANTIC MILL
Dia of Cyl. 26 ins. Stroke 4 feet. 60 revol.



Babcock & Wilcox Engine KINGS COUNTY FLOUR MILL
Dia of Cyl 22 ins Stroke 42 ins 70 Revol.

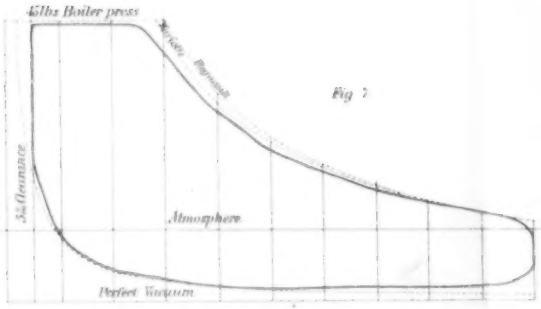
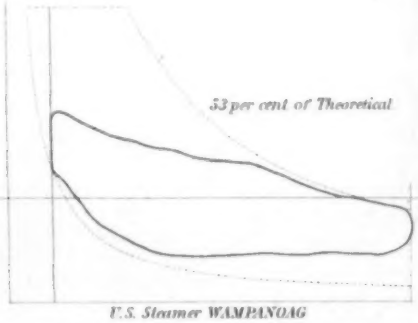


Fig 7



U.S. Steamer WAMPANOAG

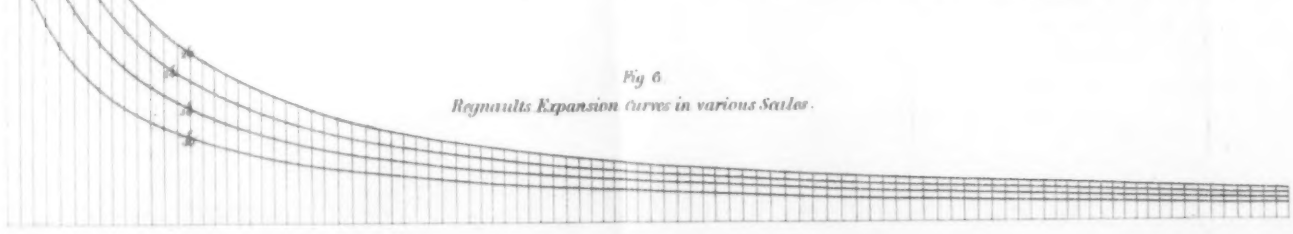
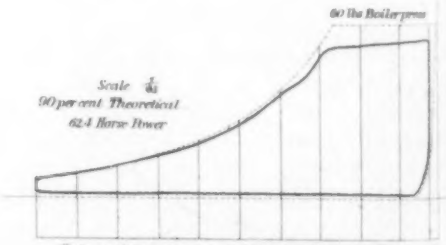


Fig 6.
Regnaults Expansion curves in various Scales.



Babcock & Wilcox Engine ROGER WILLIAMS MILL
Dia of Cyl. 14 ins Stroke 4 feet 60 Revol.

Lith. by James McGuigan, Philadelphia

But it should be remarked here, that the indicator diagram does not show the full quantity of steam used under any circumstances; as there is more or less water evaporated from the interior surfaces of the cylinder during the return stroke of the piston, while the exhaust valve is open, the steam from which evaporation does not show on the diagram, but nevertheless carries off a quantity of heat that has to be replaced by the condensation of more live steam, while the induction valve is open, on the return stroke, and this steam also is unrepresented upon the diagram. Again, there may be, and often is a leak from the cylinder either past the piston or exhaust valve, during the forward stroke, which may be detected by, but is not measurable upon, the diagram, although a leak into the cylinder is shown by a higher terminal pressure. There is, consequently, a quantity of steam used which it is impossible to estimate by means of the indicator alone, the effect of which upon this investigation will be considered hereafter.

Having assumed, therefore, that the terminal pressure represents a sufficiently near approximation to the quantity of steam used in developing the power represented by the diagram, we will proceed to construct a diagram of a theoretical engine of the same capacity, including clearance, as the engine under consideration, and having the same terminal pressure. But in order to do this, we must first know the pressure of steam in the boiler, and the clearance in the cylinder and passages. The former is generally given on the diagram, and, where practicable, should be corrected by testing the gauge with the indicator spring. The clearance is, however, rarely given, and varies in different engines from $1\frac{1}{2}$ to 10 per cent. of the space swept through by the piston in one stroke. If we have the drawings of the engine we can calculate it; if we know the style of engine we can approximate it; and if there is any compression, we can estimate it from the diagram, by assuming any two convenient points in the curve, measuring the pressure from absolute vacuum at those points, and their distance from a line vertical to the vacuum line, and touching the end of the card; thus in Fig. 1, let p = pressure and d = distance of the first point, or the one farthest from the end of the diagram, p' and d' = respectively the same quantities for the other point, and x = the clearance, then $(x+d)p=(x+d')p'$ and thence we have the formula $x=\frac{pd-p'd'}{p'-p}$

p and d may be measured in any convenient scale, and x will be in the same scale as d. Or we may determine the clearance geometrically by the following construction; (see Fig. 2.) Assume two points A and B in the compression curve, and connect them by a right line A B, continuing this line until it cuts the line of no pressure, F E at E. Draw A D and B C perpendicular to F E, and make F D = C E. Then F is the end of the theoretical diagram including clearance, and the distance of F from the boundary of the indicator

diagram is the clearance in the scale of the length of the diagram, which represents the stroke of the piston.

Having determined the clearance, we proceed to lay out the theoretical diagram as follows: We first draw a line representing the boiler pressure, which is given in the scale of the instrument, and also a line of no pressure or perfect vacuum, at 14·7 pounds from the atmospheric line, unless the true barometric reading is given. We then divide the length of the diagram, including clearance, into a number of equal parts, generally ten, though any number will answer. We next measure the pressure at the point of exhaust, which is usually a little before the end of the stroke, and find the terminal pressure therefrom either by the inverse proportion of the distance from the commencement of the diagram to the whole length, or by the method shown in Fig. 3, in which A B is the length of the diagram including clearance, and the line of no pressure, and D is the point of exhaust. Draw D E parallel to A B, and join A E cutting D C at F. Then draw F G parallel to A B, and B G will represent the true terminal pressure, or in other words, the tension at which a quantity of steam equal to the whole capacity of the cylinder and clearance is discharged at the termination of the stroke.

Having thus found the terminal pressure, the pressure at any other point of the stroke is easily found by the usual formula, or what is known as Mariotte's law, in which the pressure increases inversely as the distance from the commencement of the stroke. Where there are ten divisions of the diagram, the several ordinates of the expansion curve may be obtained by multiplying the terminal pressure by the following series of numbers: 1·, 1·11, 1·25, 1·429, 1·667, 2·, 2·5, 3·333, 5·, 10. Having found the theoretical pressure at each of the several divisions of the diagram, we then trace a curve through these points, and where the curve thus found intersects the line of boiler pressure, is the point of theoretical cut-off at which the admission of steam must be suppressed in our theoretical engine to give the same terminal pressure.

On the return stroke, if there is no compression, the theoretical diagram will follow along the atmospheric line or the line of absolute vacuum, according as the engine from which the diagram was taken is non-condensing or condensing, and will extend to the clearance line, and up that to boiler pressure. But if the exhaust valve closes before the end of the return stroke, and a quantity of steam is imprisoned in the cylinder to form a cushion, then so much of the cylinder full of steam as is thus imprisoned, is not discharged, but remains in the cylinder, and must be allowed for in our theoretical diagram. We therefore draw a hyperbolic curve tangent to the actual compression line, and extending to the line of boiler pressure, which curve forms the boundary of the theoretical "card." If the engine is condensing, this curve will also extend to the exhaust line, and will form the boundary of the theoretical diagram both on the bottom and at the end. If non-condensing the atmos-

pheric line will bound the diagram until it intersects the compression curve.

We now have two diagrams tangent at two points—the compression and exhaust—the one always larger and enclosing the other. The inner one represents what the steam actually performed in the engine, the outer one what the same amount of steam should have done in a perfect engine of the same capacity; and the proportion which the area of the smaller bears to the larger, gives a very good idea of the relative perfection of the mechanism which was used for developing the power of the steam. This may be expressed in percentage of the theoretical, and a collection of diagrams so figured, the arrangement of valve-gear in each case being fully noted, is very instructive.

To facilitate the construction of these theoretical diagrams, Mr. A. H. Raynal has devised the scales shown in Figs. 4 and 5. Fig. 4 is for laying off the hyperbolic curve of expansion with rapidity and without the mental effort incidental to mathematical calculations. It is simply a series of secants numbered from the vertical, whose tangents are to each other inversely as their numbers. In using this scale, which answers for all scales of pressure, and any number of divisions of the diagram, we take the terminal pressure in the dividers, or on a slip of paper, and find with which of the vertical lines it corresponds, at the secant corresponding with the number of parts into which the diagram is divided; and each of the other pressures will be found at the intersection of its corresponding secant with the same vertical line, and may be transferred directly to the divisions of the diagram. Should the number of divisions exceed ten, the dotted secants are used. They also serve for semi-divisions of the diagram, where accuracy requires them; as where the point of cut-off is quite early in the stroke. It is not essential to determine the terminal pressure in all cases, but frequently it will be sufficient to take the pressure at the 9th, or any convenient division, and from that point lay off the curve each way.

Fig. 5 is a device for laying off the divisions of the diagram, including clearance, the length of diagram and percentage of clearance to stroke being known. It is a diagonal scale with one of the divisons subdivided in a progressive ratio. In using it, the length of the indicator-diagram is taken on a slip of paper, and so placed upon the scale, that while horizontal one end rests upon the subdivision which represents the percentage of clearance, while the other end is at the extreme line of the scale; the several principal divisions of the scale are then marked on the slip of paper, the distance of the exterior line from the percentage subdivison mark being the clearance in the same scale as the stroke. Where the length including clearance is given, this scale is used simply as a proportional scale of parts. With this is given a scale of 14·7 pounds in various scales of pressure, a very convenient adjunct for laying down the line of no pressure or perfect vacuum.

Let us now consider briefly, the effect of condensation and leak-

age of the piston or exhaust valves; and whether these so modify the results obtained by this mode of comparison as to render it of little value.

Of course, any cause which lowers the terminal pressure, will decrease the size of the theoretical diagram in any given case, and thus give the engine a higher than its proper rate. Leakage from the cylinder produces this effect, and when this exists to any considerable extent, the diagrams are worthless for any other purpose than as a measure of power. As the amount of such leakage is not measurable upon the diagram, it is important, when diagrams are taken for the above investigation, or in fact for any purpose, that this point should be determined. This may be done by blocking the engine upon either half stroke, and letting on a full head of steam. By then examining the exhaust, the leakage, if any, will be detected, and may be measured by causing it to be condensed in cold water, weighing the water both before and after a given time; or by noting the rise in temperature of a given weight of water.

But the question of reëvaporation of condensed water within the cylinder while the exhaust-valve is open, is not so easily determined. It may be, and has been measured, by using a surface condenser weighing the water discharged therefrom and comparing it with the weight of steam exhausted, as determined by the capacity of the cylinder and passages, and the specific weight of steam at the terminal pressure, and has been found to vary from 9 to 50 per cent. of the whole amount of steam used, according as means for its prevention have been used or neglected.

This loss, if measured and accounted for in the theoretical diagram, would reduce the apparent rate of the engine; but as it is nearly the same in all cases, having the same amount of protection to the cylinder, and is in a measure independent of the mechanism of the engine, we may ignore it in the foregoing calculation, without seriously affecting the value of the latter as a means of comparing the efficiency of one engine with another. But we should bear in mind in such comparison, that the effect of this practically unavoidable loss is, in all cases, to belittle the performance of an engine having a good degree of expansion within the cylinder when compared with one having little or none; because, in the former, a portion of the reëvaporation occurs during expansion, and enters into our calculation. We should also remember that when a steam-jacket is employed, its usefulness is not fully apparent in this mode of comparison, for the principal benefit of the steam-jacket being to lessen the loss by condensation, and to increase the proportionate reëvaporation during expansion, the saving in condensation is not represented, while the increase of reëvaporation during expansion raises the terminal pressure, and thus lowers the percentage of the indicator diagram.

It will be seen that in this mode of comparing the performance of engines, the questions of the relative economy of expansion or non-expansion, of high or low pressure, condensing or non-conden-

sing, are not mooted; the comparison merely being as to the relative value of the mechanical arrangement for utilizing the steam used at the particular pressure, and degree of expansion, and under the circumstances which are employed in the engine. But it clearly shows why an engine which admits the steam at or near boiler-pressure, and automatically cuts it off at a point in the stroke proportionate to the load, is more economical than one which has a fixed or no cut-off, and a variable load, the power and speed being regulated by a throttle-valve. It also shows graphically the benefit of large passages and pipes, a tight, quick moving valve, and a proper amount of compression.

This mode of expressing the value of mechanical arrangements in steam-engineering, was first published, it is believed, in a pamphlet issued by the firm of which the writer is a member, about a year ago. As it was not practicable in the limits of an advertising pamphlet to fully elucidate the grounds upon which the comparison was based, and because many even among the profession do not seem to understand the mode of delineating the theoretical diagram, I have taken the present occasion to enter into a more explicit description and explanation of what I believe to be a new and interesting investigation.

In the foregoing, I have assumed that steam expands according to Mariotte's law, for the reason that were it a perfect gas instead of vapor, it would follow that law in its expansion, and it is not improper, for the purpose of comparison, to so consider it; while that law admits of a ready construction of the theoretical diagram without the necessity of tables or pressures, or the use of logarithms. But should any one prefer to use the modified law of expansion of steam deduced from the experiments of Regnault, the Franklin Institute and others, it can be done by employing the tables of pressures and volumes given in most collections of engineering formulæ. To facilitate this, I have constructed the scale shown in Fig. 6, which is a series of expansion-curves, as per such tables, laid down to different scales of pressures. The terminal pressure having been ascertained, the same is found on the curve having the same scale of pressure as the indicator diagram. The distance between that point in the curve and the line of no volume is then divided into as many divisions as there are in the diagram, and at each division will be found its corresponding pressure.

This curve may be also described by first finding the ordinates of a hyperbolic curve, based on a terminal pressure equal to the 0·941 power of the true terminal pressure, and then extracting the 0·941 root of each of these ordinates.

The curve thus found is always exterior to that derived from Mariotte's law, as is seen in Fig. 7, which is a diagram fully developed in accordance with the foregoing directions, and with both curves of expansion delineated. Several diagrams from various engines, compared in the foregoing manner are appended to illustrate the principle.

SOLAR ECLIPSE—AUGUST 7, 1869.

The Philadelphia Photographic Expedition.

In consideration of the fact that the services of all members of this party were entirely gratuitous, and that even much expense was saved to the Government by the loan of apparatus, and in other ways, through the means of its members, Prof. Coffin has given his consent to the publication of results obtained by them, in anticipation of their official announcement through his department. We are thus enabled, at this early date, to furnish our readers with a full account of all that was done by this expedition.—[Ed.]

Philadelphia, *August 18th*, 1869.

Prof. J. H. C. Coffin, U. S. N.,
Superintendent of Nautical Almanac, Washington, D. C.

Sir:—On receipt of your letter of May 3d, in which you proposed that I should undertake the organization and conduct of a party to make photographic observations of the total eclipse of August 7th, I proceeded to make inquiry as to the material which might be available for the purpose and in concert with, and, assisted by yourself and Prof. E. O. Kendall, found that we might readily procure two fine Munich Equatorials of 6-inch aperture, and with clockwork, belonging respectively to the High School of this city and the Pennsylvania College at Gettysburg, and also an excellent Dolland of 4-inch aperture equatorially mounted, but without clockwork, belonging to the University of Pennsylvania in this city.

On further consultation with yourself, it was concluded that on account of the risk of local clouds, it would be desirable, if possible, to take all these instruments and distribute them over some distance on or near the central line.

On careful reflection, I came to the conclusion that at least five skilled operators would be necessary to each instrument, and that, therefore, something must be done to diminish the expense of transportation, or the government appropriation available for this department of the general eclipse observations, would be insufficient.

It also appeared that some arrangement by which trans-shipment of the numerous weighty and delicate pieces of apparatus might be avoided, would be highly conducive to success and security.

SOLAR ECLIPSE, AUGUST 7th, 1869.

I therefore called upon my friend, Mr. R. H. Lamborn, Secretary of the American Steel Manufacturing Company, whose extensive connection with our great lines of interior transportation would give him opportunity of affording the best advice, and explained to him my ideas. He went with me at once to Col. Thomas A. Scott, Vice-President of the Pennsylvania Central Railroad, and stated the case to him with admirable brevity and precision.

Col. Scott, with the greatest kindness, acceeded at once to our request, and promised to provide us with a special car, from which some seats should be removed to accommodate our apparatus, and which should go with us to the end of our route, and there remain until our return. Free transportation over the entire route of the Pennsylvania Central and Ft. Wayne Railroads (*i. e.*, as far as Chicago,) for our party, and several others beside, was included in or added to this generous gift.

I then wrote to Mr. Robert Harris, of Chicago, General Superintendent of the Chicago, Burlington and Quincy Railroad, asking him to forward our car and its contents over the road in his charge. To this he also most kindly agreed, and, in fact, facilitated our movements in every way, sending a locomotive to meet us at the intersection of his road with the Pittsburgh, Fort Wayne and Chicago line, and carrying us to the depot for Burlington on our way out, when we were pushing through rapidly, and transferring our vehicle again on our return journey. Mr. Norton, from Mr. Harris' office, also met us at the junction, to explain the proposed disposition, and kindly acted as our guide through the city.

Provision being thus made for transportation, by which an expense of about $15,000 was spared to the government appropriation, the plan of taking out a triple party became feasible, and was accordingly adopted.

The next point was the selection of the party, and this was proceeded with at once, communications being exchanged with many of our leading photographers and others, to learn their views and inclination. It was soon found that an excellent selection might be had from among those whose position or engagements would allow them to volunteer without other compensation than the moral one contingent on success; and after a few changes, rendered necessary by sickness or other inevitable cause, the party, as finally constituted, consisted of Prof. A. M. Mayer, Ph. D.; Prof. C. F. Himes, Ph. D.; Messrs. J. Zentmayer, O. H. Willard, E. L. Wilson,

H. C. Phillips, E. Moelling, J. C. Browne, W. J. Baker, James Cremer, H. W. Clifford, O. H. Kendall, J. Mahoney, W. V. Ranger.

We were also joined, as volunteers, on the ground, by Mr. John Corbutt, of Chicago, and Mr. Miles Rock, of Bethlehem, Pa., and Mr. Leisenring, of Burlington. Prof. Coffin having suggested that some general physical observations should be carried out in connection with this party, I applied to Prof. E. C. Pickering, of the Massachusetts Institute of Technology, Boston, who consented to take charge of these, and accompanied us to Mt. Pleasant, Iowa, as will be seen from a subsequent portion of this report. Prof. James McClune, of the Philadelphia Central High School, and Prof. S. G. Gummery, also accompanied the expedition, and were stationed at Oscalousa.

The next point to which attention was directed, was the arrangement of the instruments for their photographic work. It was a question of much moment, to decide whether we would follow the plan adopted by the French and German expeditions of last year, and make the photograph in the principal focus of the object-glass, thus securing great intensity of light in a small image, or follow the method employed by De la Rue in 1860, when he used an ordinary Hygenian eye-piece so placed as to produce an enlargement of the first image from the objective.

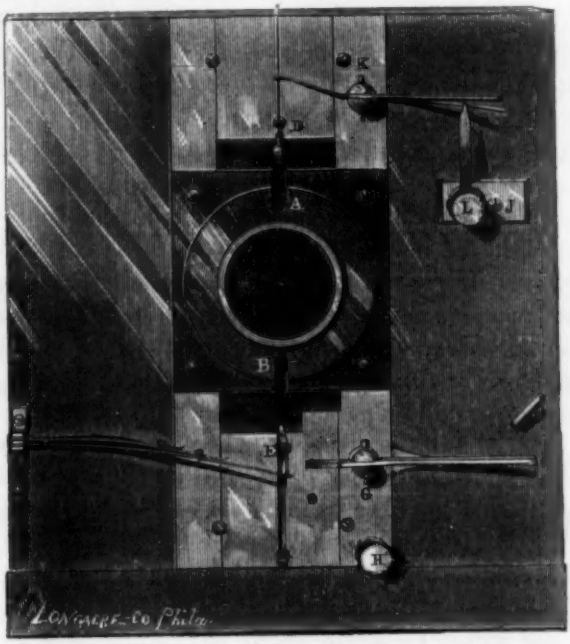
After a careful study of De la Rue's report and pictures, as also those of the later expeditions, I came to the conclusion that the plan of enlargement presented many advantages, and should be followed by us with certain modifications, which I will proceed to describe.

The work of designing and constructing these lenses, and also the different attachments to the cameras for securing exposures of various degrees of rapidity from a very small fraction of a second to any desired length, was placed in the hands of Mr. Joseph Zentmayer, whose extended scientific attainments, combined with unrivalled skill in the construction of optical instruments, peculiarly fitted him for such a task.

The camera, as finished, is represented in the accompanying woodcut, which shows it as seen from directly in front.

Here A B represents the face-plate of the camera, to which the eye-piece tube was attached, its other end being screwed to the telescope. The diaphragm plate, D E, moved across the axis of the

instrument, being drawn downwards by the combined spring, E F. The strength of this spring could be reduced by raising the outer end of one or both the upper strips so as to disengage the forks at their end from the lower spring, and then turning them forward in a direction normal to the front of the box, out of the way.



The spring was attached to the diaphragm plate by a swivel hook, which, while in no instance falling out, could be detached and readjusted with the greatest facility.

A number of diaphragm plates were provided, with slits respectively of $\frac{1}{40}$, $\frac{1}{30}$, $\frac{1}{20}$ and $\frac{1}{10}$ of an inch in width. These plates could be readily interchanged, and, in combination with the springs, gave a very wide and yet delicate series of fixed adjustments for the times of exposure.

To make the exposure, the plate was drawn up until the projecting pin, D, could be caught on the lever, K, which would then retain it. On depressing the outer end of this lever, however, with the finger, the hold on the pin was disengaged, and the plate flashed across the axis of the tube, allowing light to traverse the narrow slit as it flew past. The plate was then arrested on the end of the

second lever, G. When an exposure of some seconds was required, as during the totality, a plate having a round orifice exposing the entire field of the eye-piece was substituted for the one with the narrow slit, and was so arranged that, when caught by the upper lever, it covered the lens, but when fallen to the second lever, exposed it entirely; when, however, this lever was in turn touched, the plate descended again far enough once more to close the lens. By touching these two levers in succession, it was then possible to make a "time exposure" with great nicety and accuracy, as proved by actual experience during the eclipse.

To secure a chronographic record of each exposure, a binding screw was provided to make one connection with the general mass of the face-plate including lever K, and another at L, to carry on the circuit when the downward motion of the lever brought the spring at its side in contact with the point projecting from L. In raising the lever for a new exposure, the spring at its side was pressed back so as to pass the point without contact. A more substantial break-piece would have been made, had time allowed, but this was found to operate in a perfectly satisfactory manner.

As the operation of the eye-piece, when employed to produce an image on the screen or ground glass of a camera, is essentially different from that which it performs in its usual office, it was judged best, by Mr. Zentmayer, to make some alterations in its form. Thus, in the first place, since in the present case the "eye-lens" of the eye-piece undoubtedly makes a secondary image of the primary image formed within the eye-piece by the combined action of the objective and the field lens of the eye-piece, it is clearly desirable to make this lens of a longer focus than usual, so that its errors may be of less account. It was also essential to give the new eye-piece a wide angle, so as to secure a sufficient field not only for the solar disc, but also for the corona.

While, therefore, the ratio of focal lengths in the two lenses of the ordinary eye piece is usually 1·3, it was, in this case, as 1·2. While the distance between the lenses is usually the sum of their focal lengths divided by 2, it was here made equal to the sum of the focal lengths divided by 2, plus ·24 inch. This was to give space for the introduction of the reticule of spider lines which would otherwise have been brought too near the field lens, and also to keep this lens beyond the conjugate focus of the eye lens,

as otherwise particles of dust on the former would have been too faithfully portrayed by the latter.

The elements actually adopted were as as follows :—

	ft.	in.
Focal length of Objective	8	6
Radius of Field Lens		1·375
" Eye Lens		0·687
Focus of Field Lens		2·6
Diameter of Field Lens (= R)		1·375
Focus of Eye Lens		1·3
Diameter of Eye Lens (= R)		0·687
Distance between Lenses, 1·95 + 0·25		2·2
Equivalent		1·75
Distance of Reticule from Eye Lens for 5-inch distance of ground glass		1·62

The reticule was mounted on a short tube with a fine thread on the outside running in a corresponding thread on the inside of the eye-piece tube. This being approximately adjusted beforehand, was moved to its exact place by turning it with a sharp point through a little slot cut in the eye-piece tube.

One of the cameras with its eye-piece, being finished, experiments were at once made with the telescope of the University of Pennsylvania, which by reason of its smaller size, was most readily available for such purpose. These were conducted by Mr. Willard, Mr. Zentmayer, and myself, at the establishment of Mr. Willard, 1206 Chestnut Street, where all conveniences for the work were at hand, and were of the greatest value in affording data on which the construction of the other apparatus could be based.

It was found that, with a clear sun, it was necessary to reduce the aperture of this telescope (which was 4 inches, with 50 inches focus,) to $1\frac{1}{2}$ inches, and to use all three springs and the diaphragm-slide of $\frac{1}{40}$ inch aperture, in order to get a proper exposure when the solar image was enlarged from ·6 inch (its diameter at the principal focus of the objective) to $2\frac{1}{2}$ inches on the ground glass. The same size of aperture was adopted for the larger instruments during the partial phases, the entire aperture, in all cases, of course, being used during totality.

There being no place in the city where the larger instruments could, with convenience, be set up, adjusted, and practiced with by the party who were to use them, I applied to Mr. John Sellers for permission to use a very conveniently located portion of his grounds

in West Philadelphia, and having prepared a design for a temporary building, (with roof, in part, removable by sliding,) caused it to be erected, and had the large instruments set up in it.

Matters being thus far advanced, Prof. A. M. Mayer, Ph. D., of the Lehigh University, Bethlehem, Pa., who had agreed to join our party, came down to the city and spent some days here, during which the telescopes were adjusted by him, in a very perfect manner, by a rapid and convenient method, which has been made the subject of a full discussion by him, as will be seen in his own report appended hereto.

A number of experiments were made by Mr. Willard, at this time, in photographing the moon, which were of great value in settling the time of exposure which would probably be required in the total phase.

He found that a good impression could be obtained of the full moon in about one minute, and that an abundantly strong one could be secured with an exposure of three minutes. From this and the deductions of De la Rue, that the light of the prominences was 180 times as great as that of the full moon, it appeared that an exposure of from $\frac{1}{3}$ of a second to 1 second, during totality, would have been sufficient to secure images of these bodies. For the corona, of course a much longer exposure would be required; but no estimate could be made as to what would be its duration.

In connection with these experiments, it is but just that I should call attention to the unwearied patience and enthusiastic energy with which Mr. Willard devoted himself to the prosecution of this preliminary work. Day and night, whenever any observations were to be made, or any experiments tried, he was on the ground, and on certain occasions displayed an energy and determination, combined with sound judgment, seldom to be encountered. Thus, it becoming desirable to shift the position of the building in which the telescopes were placed, he arranged and accomplished this in a most successful manner, though the operation was considered, by the professional builders present, impossible without derangement of the instruments.

Mr. O. H. Kendall also rendered invaluable services in connection with the preliminary arrangements.

Much interruption was experienced from bad weather after this, but the rainy days were utilized by Mr. Zentmayer in putting the driving clocks of both instruments (which were in very bad order)

in admirable adjustment, so that, on the few occasions that the sun *did* shine, enough work was done by the rest of the party to make them familiar with the necessary manipulations.

The instruments were dismounted, boxed, and packed in the special car furnished us by Col. Scott, on Saturday, July 31, when it was found that, with the various photographic appliances, they made no less than five furniture car loads of material.

On Monday, August 2d, we started, and on Wednesday, the 4th, about noon, reached Burlington, Iowa, on the bank of the Mississippi.

In arranging the division of our party into three sections, with the three telescopes, so that they might be distributed along the line of totality, and thus diminish the chance of universal extinction by local clouds, I was chiefly guided by the desire of securing in each section such a diversity of special ability as might make each self-dependent and complete; also, to leave nothing undone to secure content and harmony of feeling. I assigned myself to the University telescope, which, being of smaller size, and without clockwork movement, could not be expected to do as good work as the others; though, should *they* by chance be overclouded, *its* result would be invaluable.

I therefore divided the party as follows:—

With the High School telescope, 6-inch aperture, 9 feet focal length, Prof. A. M. Mayer, Ph. D., and Mr. O. H. Kendall in charge of the adjustment of the instrument and management of the apparatus for exposures, and Messrs. O. H. Willard, H. C. Phillips, and J. Mahoney having charge of the entire photographic work. This section was stationed at Burlington, 40° 48′ 17″ N., 0 h. 56 m. 14 s. West of Washington.

With the Gettysburg telescope, 6-inch aperture, 8½ feet focal length, Prof. C. F. Himes, Mr. J. Zentmayer, and Mr. E. Moelling in charge of the instrument, &c., and Mr. J. C. Browne and Mr. W. J. Baker, who managed all the photographic processes. This party was stationed at Ottumwa, about seventy-five miles nearly west of Burlington.

With the University telescopes were Mr. E. L. Wilson and myself, in charge of the instrument, and Messrs. H. W. Clifford, James Cremer, and W. V. Ranger, as photographers. We were also joined by Mr. John Carbutt, of Chicago, as a volunteer, who gave us most efficient aid. This section was placed at Mt. Pleasant, be-

tween the other stations. The various parties having reached their destinations during Wednesday, arrangements were at once made to get the instruments into position in the locations previously prepared by Prof. Coffin. In the case of the Burlington party, all went smoothly, and the dark weather alone prevented final adjustment until the night of the 6th or morning of the 7th, when this was secured with great nicety by Prof. Mayer, who sat up all night for the purpose.

With the Ottumwa instrument it was, however, found that the clockwork had become seriously deranged in carriage, so that Mr. Zentmayer was obliged to take it entirely apart and refit it. This he accomplished with great success, and it may be regarded as one of our many pieces of providential good fortune, that since one of the clocks was to go wrong on the journey, it was that one which was within reach of this gentleman's skill. The trouble and anxiety which this cause of delay occasioned, was, however, no small trial of fortitude to the Ottumwa party. The final adjustment was also given to this instrument during the morning of the 7th, by Mr. Zentmayer, who had watched all night, vainly, for a star.

This party, beside the above-mentioned difficulties, were unable to obtain any expert assistance on the ground, from resident photographers and others, as was done by both the other divisions, so that they were left entirely to their own resources, and acquitted themselves, under the exceptional difficulties of their position, in a most creditable manner.

In this connection, special reference should be made to Prof. C. F. Himes, who, by his skill, judgment, and coolness in a serious emergency, (occasioned by accidental derangement of the chronograph attached to the telescope,) preserved the record of this series of pictures which must, otherwise, have been in great part lost.

The telescope at Mt. Pleasant having no clockwork, and being otherwise unfit for any fine adjustment, required no arrangement, except what could be given during the morning of the 7th.

As all know, the weather on the eventful day of the eclipse was, at all our stations, perfect, so rendering needless, but none the less judicious, our policy of distribution.

At the Burlington station, a photographic record of the first contact was secured, by exposing plates, in rapid succession, about the calculated time. A very good result was thus obtained.

At Mt. Pleasant, we placed a plate ready in the camera, and then

waited a signal from Prof. Watson, of the University of Michigan, who, with his party, was on the ground with us, and was watching for the first contact. We thus obtained a picture showing a very slight indentation. By measurement of this, the time of *actual* first contact can be reached by calculation, yet more precisely than would be possible with any eye observation.

During the partial phases, accurately timed exposures were made by all parties, at intervals varying from a few seconds to ten minutes.

Partial-Phase Pictures.

These pictures show the various sun-spots visible at the time (about six in number) with admirable definition, the larger ones being surrounded by a marked fringe of faculæ, and give, also, a distinct granulation over the general surface of the sun.

They all show an increase of light on the solar surface, where it is in contact with the edge of the moon. This, which would seem to indicate, according to Prof. Challis,* the presence of a very rare lunar atmosphere, is unmistakably manifest on all the negatives, and confirms the observation made by Prof. Stephen Alexander, in 1831 and 1860, when he noticed it on the photographs that were then taken.

De la Rue observed something similar in 1860, which he considers a subjective effect; but this explanation will clearly not apply to the present case, where it is evidently a question of deposited silver, and not contrast of light and shade.

Totality Pictures.—The Prominences.

During the totality thirteen pictures, in all, were taken with the three instruments. Of these, six were made at Burlington, with exposures of five to seven seconds; four were made at Ottumwa, with times of exposure ranging from six seconds to sixteen.

These are all admirable negatives, which show abundant detail, and, in some cases, much of the corona. Three pictures in totality were also made at Mt. Pleasant, but, for want of a clock-movement, are inferior to the others. One of the Ottumwa pictures, exposed at the very last instant of totality, shews a photographic record of the curious phenomenon known as Bailly's beads, being simply the last glimpse of the sun's edge cut by the peaks of lunar mountains into irregular spots.

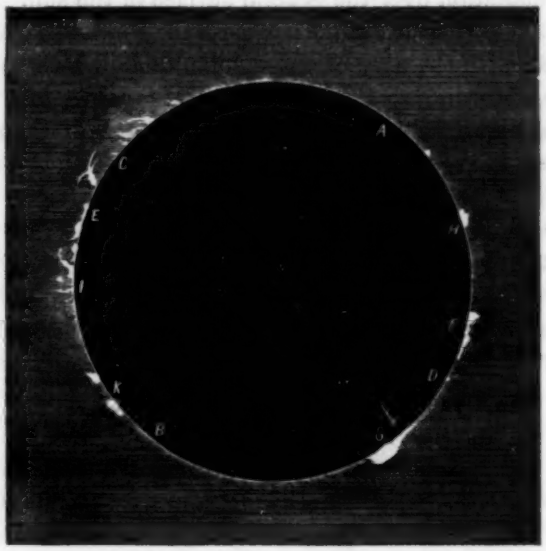
One of the objects which it was considered desirable to secure, if

* See *Monthly Notices* of the Royal Astronomical Society, 1863, p. 234.

possible, was a view of the corona. It was with this intent that some of the exposures were made so long.

Examination of the negatives shows us that five seconds was more than sufficient to secure all the details of the protuberances, although it gave no decided indication of the corona.

The development proceeded slowly in all but a few spots where very massive prominences were located, and thus it was not thought, at the moment, judicious to try shorter exposures; but, in the light of our present experience, we would judge that exposures of even one or two seconds, with persistent development, such as could be best carried out on albumenized plates, would be of value to secure details in the rounded and massive prominences which appear at some points.



It is a curious coincidence, that in this case, as well as in the pictures made by De la Rue, in 1868, and the German and English party last year, all the more interesting prominences are situated on the border of the sun furthest from the advancing moon, and are thus best shown in the pictures first exposed. Thus, we have selected half of the first totality picture taken at Burlington, to be used as an illustration in this place, as enabling us to give it a large size without exceeding the limits of our page, and yet secure nearly all that is of interest.

The most conspicuous prominence is that which, at a hasty glance, seems to resemble the letter X, but, on more careful inspection, is perceived to be like an ear of corn. It consists of a solid central mass inclined at an angle of about 45° to the normal at the solar surface, and with three branches from near its upper end, one sweeping backwards in a direction generally parallel to the solar surface, another forward, as concerns the direction of the general mass, and a third branching out a little below and running in the same direction as this last. The appearance of the main body, which is of a spindle shape, and with spiral markings, is highly suggestive of a vortical motion which has swept these whiffs of light matter into their peculiar positions.

It was believed by several observers, that this object moved rapidly while they were watching it; but as the same positions are shown in the eight different negatives, (taken at Burlington and Ottumwa,) which contain it, there can be no doubt of its permanent character.

It appears, however, beyond doubt that motion, amid the light surrounding the sun, was observed, as there is much accordant testimony on the subject. But this motion, as we shall presently see there is every reason to believe existed in the corona, and not in the prominences, which, however, might easily have the appearance of movement, if seen against a background of shifting light. To this subject we shall refer again when speaking of the corona.

Immediately to the right of this ear of corn, is seen a region of soft light, among which rise two similar spindle-shaped masses inclining towards the corn ear.

To the left appears a mass of rolling cloud disposed in beautiful streams and curls, like the smoke from a bonfire or burning meadow, swept gently toward one side by a light wind. In connection with these are some small masses, entirely detached and floating above the general body, as was the case in De la Rue's pictures.

Other solid nodular masses appear at other points; but the next most notable prominence is one which attracted the attention of all observers, and appeared to occupy a position on the lowermost edge of the sun. It is most clearly shown in the last pictures taken at each station, and resembles, in shape, a great whale with a body made up of dense cumulous cloud matter, with a long tail clinging close to the solar edge, and stretching some 40,000 miles along. The length of the entire mass is about 110,000 miles, and

the height of its more bulky portion about 28,000 miles, while its length being about 70,000 miles, we would have for its cubic capacity, assuming that its extent in the remaining direction is equal to its height, about 54,880,000,000,000 cubic miles.

To the right of this, and only showing its entire length in the last picture of each series, is a caterpillar-like mass of cloud matter, very much like the solid rolls of horizontal vapor which are sometimes seen passing over a sheet of water. At one end rises a projecting head, but the rest clings closely to the solar edge, and is indented with ring-like divisions, giving it much the aspect of a huge worm.

The Corona.

The Ottumwa pictures, of long exposure, are the only ones which give us any idea of the true structure of the corona, but they do more than I had hoped in this respect. One of them, the last and longest exposed, gives almost as full a development to this object as I remember to have noticed with the naked eye; the curved structure of the rays, and the varying intensity with which they are emitted in different points, is most marked.

The brightest outbursts of the corona light are evidently associated with those prominences which are of a pointed and flame-like shape; those of a massive description, on the contrary, seeming to cast a shadow on the corona; this, we think, is to be noticed in De la Rue's pictures.

These facts have peculiar significance, when taken in connection with others developed by observations made during this same eclipse. In the first place, Prof. E. C. Pickering, of the Massachusetts Institute of Technology, who was with our party at Mt. Pleasant for the purpose of making various physical observations, found that while the sky was strongly polarized all around, close up to the corona, that object itself was not a source of polarized light.

The instrument employed was a tube, having at one end a large plate of quartz, and at the other a double image prism of Iceland spar, made in the manner known as the prism of Rochon.

On looking through this at the corona, the entire circle was in field with a part of the surrounding sky, and two entirely distinct images of the entire area were seen, the corona in both being colorless, but projected on a ground of tints, complementary in the two images.

This would certainly indicate that the light of the corona was not reflected sunlight. With a spectroscope arranged to analyze the entire light from the totality phase, Prof. Pickering also found no dark lines in the spectrum. This also points in the same direction.

The observations of Prof. C. A. Young, of Dartmouth College, Hanover, N. H., who was stationed at Burlington, are most conclusive. He found bright lines in the spectrum of the corona corresponding with those given by the aurora. In a letter which I have just received from him, he says:—

"Since returning, I have seen the last (July) No. of Silliman, and in it the positions given by Winlock for 5 aurora borealis lines.* You will be interested to learn, that so far as I can ascertain by graphical construction, the aurora line at 1550 of Huggins' chart exactly coincides with my principal corona lines 1474 Kirchhoff; and, moreover, the aurora lines 1280 and 1400 (Huggins), agree, as far as I can judge, with the two fainter corona lines between D and E, which I saw and recorded, but had not time to measure accurately.

"Perhaps I am too bold in my conclusions, but at present I feel persuaded that the *solar corona is a permanent aurora.*

"All three of these aurora lines are given by Angstrom as *iron* lines. What is the meaning?"

It would thus seem almost certain that the corona is simply an electric discharge, no doubt varying with great rapidity, as we see in the case of the aurora, and to its variations we may attribute those apparent motions of the prominences which have been observed by so many, but which our large series of photographs so conclusively shows not to have had any actual existence.

Appearance of Meteoric Shower.

At the Ottumwa station, a curious appearance was noticed by Mr. Zentmayer, and also by Prof. Himes, as will be seen from his report.

* *Silliman's Journal*, Vol XLVIII., p. 123. "We are indebted to Prof. Winlock for the following interesting notices. The light of the beautiful Aurora of the evening of April 15th, examined with the spectroscope, gave five bright lines corresponding in position to the following lines of Mr. Huggins' scale. 1280 (brightest), 1400, 1550, 1680 near F, 2640 near G. On the evening of June 6th, the same lines were again observed, the brightest corresponding with 1280 of Mr. Huggins' scale. These lines could readily be seen and measured with an ordinary chemical spectroscope, with the collimator pointed directly towards the heavens."

During the time that the pictures of the partial phase were being taken at long intervals, the ground glass plate was put in the camera to note any irregularities in the clock movement, should they occur.

About twenty-five minutes before the totality, Mr. Zentmayer observed some bright objects on the ground glass, crossing from one cusp to the other of the solar crescent, as indicated in the accompanying cut by the lines from A to B. Each object occupied about two seconds in passing, and they all moved in right lines, nearly parallel, and in the same direction.

These points were well defined, and conveyed to the mind of Mr. Zentmayer, who is accustomed to the use of the camera for photographic purposes, the strong impression of being images of objects, and not points of light merely.

It is, moreover, certain that the objects, whatever they might be, must (in order to have produced such sharply defined images on the ground glass) have been several miles distant from the telescope, as even a point of light at a less distance would have produced an image enlarged and with a hazy border.

After calling Prof. Himes' attention to this phenomenon, and observing the motion of some eight or ten bodies in all, Mr. Zentmayer then noticed three others coming in from the limit of the field and disappearing in the solar crescent, as shown at C, but not reappearing on the other side.

It is worthy of note, that the direction of motion in the three last of these bodies corresponded with that of the wind blowing at the time, but that of the others did not, and they are thus, as also for other reasons, unlike the plant seeds noticed some years ago by Rev. W. R. Dawes, and described in a paper published in the *Monthly Notices* of the Royal Astronomical Society for 1852, page 183.

We consider it right, however, to record the observation made by our party, as other observers, in very distant locations, have noticed phenomena, which, according to the very general report as yet published, must bear some close relation to these, and this confirmation and additional data may thus aid in some valuable deduction. If these were meteoric bodies between us and the moon, and

also beyond our satellite, their probable appearance would not be inconsistent with the observations recorded.

Before closing this report, I cannot refrain from saying a few words in reference to the members of my party.

Our labor was eminently a coöperative one, and the pleasing success which has attended our efforts is largely due to the thorough harmony of effort and the self-denial and devotion to the general cause, irrespective of individual interest, which has characterized the entire history of this expedition.

The work we had in hand was of a nature which, in the first place, required the combination of a high order of ability in many distinct branches. It was necessary that the best optical skill should be enlisted in the structure and arrangement of the lenses; —it was essential that the very best mechanical ability should be applied to the details of the various adjustments of clockwork and cameras;—the largest experience in photographic operations was equally necessary;—so, also, was a thorough and ready skill in the refined details of practical astronomy. Besides this, it came of necessity that the failure of any one would ruin the work of all, as each step must be secure, or the pinnacle of success could not possibly be reached.

Under these circumstances, when we say that we have no failure to regret, and that no reproach has had cause to be uttered, the highest commendation possible has been implied towards all and every one concerned.

Where all were unremitting in effort and excellent in execution, it is not easy, without injustice to any, to indicate the special merit developed by opportunity or trying emergency in some; but we cannot refrain from drawing especial attention to the very valuable aid which was afforded by Prof. Mayer, Ph. D., through his intimate familiarity with all the niceties and most refined improvements in practical astronomy; by Mr. Joseph Zentmayer, through his admirable ingenuity in the devising and construction of the various mechanical and optical details required in the several instruments; by Mr. O. H. Willard, through the unsparing devotion of time and energy, and the indomitable perseverance by which all the preliminary arrangements were pushed to a successful issue, and his own department developed to its highest perfection; and by Prof. C. F. Himes, through the sound judgment and presence of mind displayed on a trying and sudden emergency.

While affording gladly this special distinction to some, we repeat that all were equally meritorious, and that the work of no one would have been of the least value without the aid of the others.

I have also, on my own behalf, as well as on that of my colleagues, to thank you for that uniform kindness, courtesy, and consideration which has rendered all our relations of the most agreeable character, and made our labor of love in an equal degree a labor also of pleasure.

Very respectfully yours,

HENRY MORTON.

NOTE.—The reports from those in charge of the several departments will be published in the next number.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, June 16th, 1869.

THE meeting was called to order with Mr. Coleman Sellers, Vice-President, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the Library received at the stated meeting held June, 9th inst., from the Royal Astronomical Society, the Royal Geographical Society, the Institute of Actuaries, the Statistical Society, and the Society of Arts, London; and the Association for the Prevention of Steam Boiler Explosions, Manchester, England, l'Ecole Imperial des Mines Paris, and la Société Industrielle, Mulhouse, France; the Canadian Institute, Toronto, Canada; the Mechanics' Institute, San Francisco, California; Prof. Alfred M. Mayer, Bethlehem, Pa., and Prof. John C. Cresson, Philadelphia.

The various Standing Committees reported their minutes.

The Resident Secretary presented his regular report on Novelties in Science and the Mechanic Arts.

After a general discussion of several points, in which Mr. Robert Briggs, Mr. Thos. Shaw, Professor R. E. Rogers and others took part, the meeting was on motion, adjourned.

HENRY MORTON, *Secretary.*

Errata to Report on Eclipse.—Owing to some unexpected delays with engravings, &c., the foregoing report was finally printed without sufficient care in revision of proofs. Some errors and omissions have thus been overlooked.

Page 201, line 28, for $15,000 read $1,500.

" 202, " 13 " Gummery read Gummere.

" " " 14 " Oscalousa read Oscaloosa.

" " " 22 " Hygenian read Huygenian.

" 209, " 35 " last instant of totality, read, last instant before totality.

Page 213, line 24 for lines read line.

It should also have been explained that the woodcut on page 210 represents the general character and relative positions of the prominences shown on *all the photographs*, some being visible only on the early, others only on the later pictures. The lines A B and C D give the directions of the spider lines used in the telescope, and placed carefully in line with a parallel of declination and at right angle to the same, respectively, by observations on a sun-spot before the beginning of the eclipse. The line F E represents the direction of the moon's motion across the sun from first contact at F to last contact at E.

The prominence described as resembling an ear of corn is that between C and E on the woodcut, page 210, those about I resemble wreaths of smoke, those above C look like flames. These two portions were those that in the telescope looked like simple obtuse pyramids of white light capped with rose color. [See Items at the beginning of this Number.] H was the prominence which in the telescope looked like a mushroom. F was the one at the point of first contact seen by Prof. Young beforehand with the spectroscope and used in his beautiful determination of first contact with that instrument. G is the whale-like prominence. [See Items at the beginning of this Number.]

With reference to the photographic illustration, inserted in the foregoing report, it must be remembered that in the double copying required, and by reason of the rapid wholesale process of printing rendered necessary for a large edition, some of the more delicate details are lost. This is especially notable in the spindle-shaped prominence near the middle of this picture. On the original and on carefully prepared prints it shows three cloudy sprays or branches from its upper end having the positions indicated in the woodcut on page 210 between C and E. Much of the soft fringe of light surrounding all these large groups of prominences is also lost.